REGIONAL INITIATIVES – ASIA-PACIFIC

GUIDELINES FOR THE PREPARATION
OF NATIONAL WIRELESS
BROADBAND MASTERPLANS FOR
THE ASIA PACIFIC REGION

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Telecommunication Development Sector

ITU

Guidelines for the preparation of national wireless broadband masterplans for the Asia Pacific region

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Foreword

Ensuring that all the world's citizens have reliable and affordable access to broadband supported content and services will give rise to massive economic and social benefits. Bridging the final mile in remote and rural areas presents a particular challenge and has been identified as such by the ITU Membership. This high priority is well-reflected in the Regional Initiatives for Asia Pacific established at WTDC-10.

The use of wireless technologies is becoming increasingly feasible and affordable. In order to facilitate their development and implementation in the Asia-Pacific region, ITU has been analysing and assessing successful practices carried out in the region and elsewhere.

The results of these efforts are a series of concrete implementable Guidelines designed to serve as a shared tool for policy makers, regulators and business as they move forward together to develop coherent and comprehensive national wireless broadband masterplans.

Addressing the entire end-to-end wireless broadband ecosystem, from content creation to the provision of global internet connectivity, the Guidelines explore the full range of policy, legal and regulatory issues, including spectrum management and innovation support, and as such provide a solid basis for action.

The development and use of advanced ICTs across the Asia-Pacific region is a vital goal. I would like to extend special thanks to the Government of the Republic of Korea for the support they have given to the ITU wireless broadband masterplan project.

I have every confidence that these Guidelines will make a substantial contribution to ensuring the prioritized national implementation and regional harmonization necessary for this to be achieved.

Brahima Sanou

Director

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Executive summary

These general guidelines provide countries in the Asia-Pacific region the means to develop their own wireless broadband masterplan and the opportunity to explore wireless broadband issues as part of the development of an overall country broadband masterplan.

The three main objectives of the wireless broadband masterplan project are to:

1. Carry out an assessment of existing policy and regulatory frameworks with a view to facilitate deployment of wireless broadband technologies taking into account convergence trends and provide recommendations for future requirements in selected pilot countries.
2. Assessment of user demand and take up of wireless broadband applications, content and services in the Asia-Pacific region.
3. Examine key policy and regulatory issues including licensing, spectrum access/interconnection, deployment of new technologies, rollout of obligations, incentive based regulation, infrastructure sharing, universal service obligations and provide concrete recommendations to promote broadband wireless services vis-à-vis identified national priorities and international best practices.

This decade offers countries in the Asia-Pacific region the opportunity to become advanced ICT users, with a countrywide broadband information infrastructure, for which wireless broadband is particularly suitable due to:

- its relatively lower shared costs and coverage of geographically separated areas which do not necessarily have high population density,
- its ease of penetration, and
- its ability to deploy and rollout rapidly.

The framework detailed in this document addresses the main aspects of the wireless broadband ecosystem, from content to the provision of global internet connectivity, that can provide widespread affordable wireless broadband services.

These Guidelines cover a number of topics of analysis and recommendations including:

    (i)   global and regional context of broadband;

    (ii)   current state of play in the country's wireless broadband market;

    (iii)   need to ensure legal and regulatory certainty;

    (iv)   management of spectrum scarcity and the need to ensure harmonisation;

    (v)   technologies and innovations in wireless broadband; and

    (vi)   conclusions, recommendation and a suggested roadmap.

Many of the recommendations and insights from the Guidelines are critical to the success of a national wireless broadband policy.

Summary of the key issues in the formulation of a wireless broadband masterplan

Regulatory	• Legislation • Promote Access • Infra sharing • Mandated rules • Spectrum allocation	• How effect are current laws and regulations in promoting broadband? • Are there effective infrastructure sharing arrangements in place? Is there costly duplication? • Does the government need to consider mandating MVNOs and/or spectrum caps to prevent spectrum hoarding? • What is the most appropriate way to allocate spectrum (i.e. auction, beauty contest, etc.) to facilitate it use for wireless broadband?
Market	• No of Operators • Degree of Competition • Penetration rate • Access Targets • Retail Tariffs	• How many mobile subscribers are there relative to fixed line subscribers? • What is the structure of the market? How many operators exist and what is their current market share? Is there adequate competition among network operators? What is the level of retail tariffs? • What is the current penetration rate? What are the target penetration and access rates for the country?
Spectrum	• Future requirements • Technology neutrality • Overall Wireless Spectrum • Digital Dividend	• What are the country's forecast spectrum requirements now and for the future? Will additional releases of spectrum (including 700 MHz, and 2.3/2.6 GHz) be required in the future? • What is the trend for wireless data traffic and what is the forecast demand? • Is the country committed to technology neutrality? Eg WCMDA @ 900 Mhz • Has the country migrated to digital television and can Digital Dividend in the 700 Mhz spectrum band be secured?
Technology	• Key technologies • LTE and key spectrum • Satellite • Domestic Backhaul • International	• What is the most effective technology mix (i.e. GSM, WCDMA, LTE, satellite)? Is the government targeting key spectrum band (i.e. 700 MHz) for the use of LTE technology? • What is the country's backhaul capacity? Is further investment in a fibre backbone required? Is wireless offloading suitable? • Which technology is best suited for international connectivity (i.e. submarine cable or satellite)? What are the geographical considerations?
Content	• Language • Local content • Government online • Training	• Is government support of local content industries required? • Are local languages supported (i.e. by Unicode or ASCII characters) for online content and information? How prevalent is local language content? • Does the government have a direct online presence? Is government leading the way in terms of online engagement with its citizens? • Are digital literacy and skills being promoted in schools and universities?

Source: Author

Regulatory insights

Making spectrum available for affordable wireless broadband services, in frequency spectrum bands designated for mobile/wireless services, is a prerequisite for a good quality wireless broadband masterplan. A masterplan must make spectrum available in harmonised bands which are suitable for the provision of wireless broadband.

For developing countries, it may not be possible to use an auction as the process for determining the price for spectrum. Proposals for the pricing of, for example, 3G or 4G spectrum should be consistent with global and regional benchmarks. Some countries may need to use benchmarking studies to determine appropriate prices for 3G or 4G spectrum.

It is critical that regulators and governments work as partners with network operators, and the ICT sector in general, rather than viewing involvement in the sector as a means of revenue raising. Governments and regulators should work together to ensure a reasonable return on investments made in wireless broadband.

The role of the regulator must be to act as a facilitator rather than as a tool for intervention. This is crucial in order to create an enabling environment, regulatory certainty and a gradual reliance on market mechanisms to promote wireless broadband services. The requirements of this role include:

- developing predictable and transparent regulatory frameworks;
- promoting competition;
- encouraging investment in infrastructure;
- engaging in consultation with industry; and
- collection of statistics from operators in order to inform government decision making. This should ideally be done at least quarterly to ensure that information is accurate and up to date.

Market policy insights

Regulating to provide mobile virtual network operators (MVNOs) access to the market is likely to lead to increased offering of innovative service bundles to different segments of the population and to facilitate downstream innovations by mobile network providers in response to an MVNO market entry.

While mobile number portability (MNP) is desirable, it is not always necessary and can add considerably to costs and network complexity. When quality of service is already an issue it may be desirable to make MNP a secondary priority.

Introduction of competitive safeguards for market operators will help to ensure a level playing field and will promote innovation and development of new technologies as the chief methods of gaining a market advantage. Open access requirements will also achieve this. Investigation of both should be strongly considered alongside the creation of a masterplan.

Infrastructure sharing requirements are an effective way to ensure that resources are not wasted on duplication and that competition will be based on innovation rather than on access to equipment. They prevent an incumbent or other significant operator from foreclosing competition from rivals and would promote innovative services as a response to the increased competition they provide.

Spectrum management insights

Given the dominant position which mobile services and wireless broadband are predicted to hold in the future, the need to effectively utilise key spectrum below 1 GHz (especially the 700 MHz band) is profound. The use of sub-1 GHz is important as it provides wide area coverage at a much lower cost than other spectrum ranges. In particular, spectrum released in the process of transition from analogue to digital television transmission, called the `digital dividend' (approximately 100 MHz of spectrum in the 470 to 862 MHz range), in the 700 MHz band is ideal for wireless broadband applications.

Consideration should be given to imposing a spectrum cap and regulations to avoid spectrum hoarding by a small number of major mobile operators. These regulations should take into consideration the total amount of frequency licensed to the mobile operators for broadband.

Countries that do not currently have UHF television broadcasts, and where the 700 MHz remains relatively unused should make this spectrum available for early allocation, and ideally should allocate such spectrum early, for example, by mid-2013 in order to secure the benefits of wireless broadband as early as possible.

Technology insights

Allowing network operators to use the latest, most efficient and most cost effective technology is important on many levels. Arbitrary policy and regulatory restrictions which do not allow flexible technology choices are not in the public interest. A firm commitment to technology neutrality is critical for any successful wireless broadband masterplan. This should ideally include a commitment to use of W-CDMA technology in the 900 MHz spectrum and LTE technology in the 1800 MHz spectrum.

In order to ensure efficient network deployment, affordability of services and to reduce the visual impact of hardware, it is important to ensure that infrastructure policy is designed to minimise inefficiencies and encourage new investment.

Satellites are very important in providing wireless broadband to those customers who are away from terrestrial wireless broadband networks. Consideration of satellite networks for provision of wireless broadband services to rural and remote users, as well as providing backhaul links to local wireless broadband networks, is a necessary part of a wireless broadband masterplan. These services are often a cost effective means of providing wireless broadband and can be available in a ready to use format, minimizing installation costs and timeframes. Specifically satellites can be utilised to provide or extend cellular network connectivity in areas without access to fibre or microwave facilities or direct connectivity when mini BTS (base transceiver stations) are not economically viable.

In January 2012, LTE-Advanced and Wireless MAN-Advanced technologies were both granted IMT-Advanced Technology status by ITU. After undergoing evaluation by ITU and meeting the specification requirements, these technologies are now officially accorded 4G status. These are currently the best possible technologies for provision of wireless broadband, and their possible use should be investigated thoroughly as part of any master plan.

Content insights

The need to have applications and content in local languages cannot be over-emphasised. To secure higher wireless broadband penetration rates customers must be able to access relevant and useful applications and content in languages they can understand. These services are one of the primary drivers of demand for broadband, and without investment in them penetration rates are unlikely to grow at desirable rates.

Table of contents

1 Introduction

1.1 Project background

Under the joint partnership of the International Telecommunications Union (ITU) and the Korean Communications Commission (KCC), the masterplan for wireless broadband in Asia and the Pacific region project was launched in second quarter of 2011. The objective of this project was to assist countries in the Asia Pacific region in developing their own masterplans which will eventually provide access to affordable and reliable broadband supported content, services and applications. In essence it aims to address many aspects of the 'digital divide' by utilising wireless broadband technologies.

In the first phase, ITU sought information from governments, regulators and other key stakeholders on the policies and strategies that are being implemented for the introduction of wireless broadband in the Asia-Pacific region.

In the second phase, ITU appointed experts developed four pilot masterplans: Myanmar, Nepal, Samoa, and Viet Nam. These represent a diverse set of countries in the region in terms of size, demographics, location, and challenges (e.g. low penetration, or converting customers from voice centric services to data services etc.).

This report provides a guide to ITU Member States which were not selected as a pilot country but wish to develop their own masterplan and/or wish to explore wireless broadband issues as part of the development of an overall national broadband masterplan.

1.2 Enabling the wireless broadband end-to-end ecosystem

The key elements of the Guidelines for the preparation of national wireless broadband masterplans for the Asia Pacific region (the Guidelines) are to enable the end-to-end wireless broadband ecosystem, which provides connectivity and content to consumers (Figure 1). In essence the goal is to address aspects of the digital divide by utilising wireless broadband technologies. The key to ensuring affordable services is in addressing costs at each stage of the wireless broadband end–to-end ecosystem[1].

The Guidelines examine five key factors:

> (i) policy and regulatory aspects,
>
> (ii) technology aspects,
>
> (iii) spectrum management aspects,
>
> (iv) international connectivity,
>
> (v) facilitating content and applications.

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[1] See www.itu.int/ITU-D/asp/CMS/Events/2012/ITP2012/Scott_Minehane_Affordable_WBB.pdf for a summary presentation exploring these issues.

Figure 1: End-to-end broadband connectivity
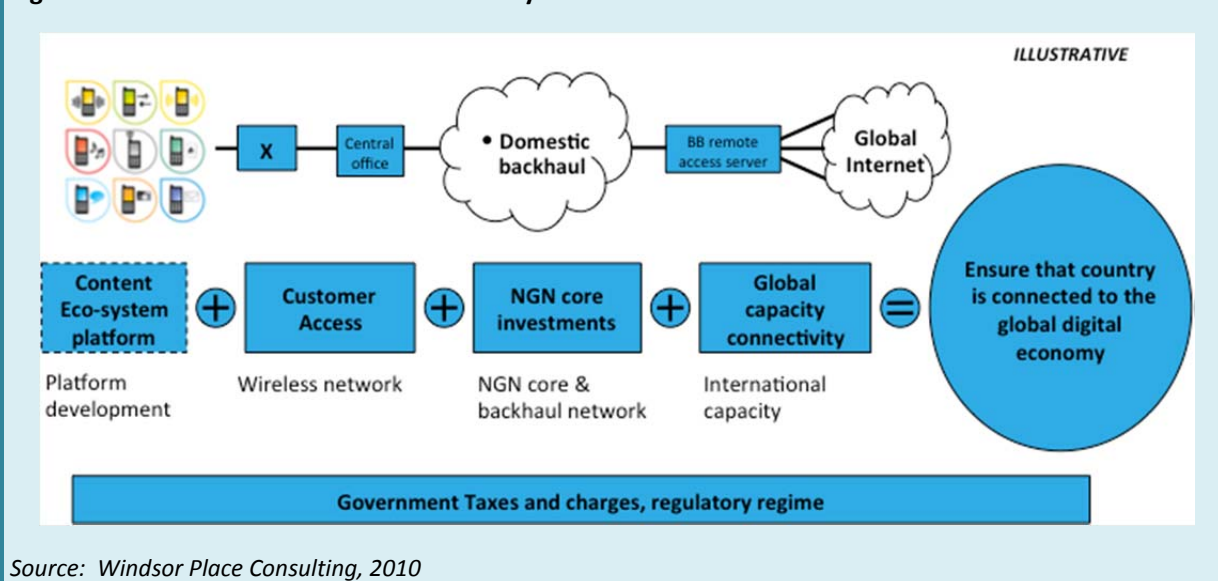
Source: Windsor Place Consulting, 2010

Should a government or regulator wish to utilise these Guidelines to develop a national broadband policy or masterplan it should be noted that these Guidelines are primarily focused on the provisioning of terrestrial wireless broadband and satellite broadband services as shown in Figure 2. Importantly depending on the fixed broadband services currently deployed in a market and able to be deployed, then the degree to which wireless broadband services complement rather than substitute for such fixed broadband services will vary. Importantly this degree of substitutability may vary over time given a range of factors include customer demand/preferences, pricing and availability of in-demand customer devices.

Figure 2: Overall market broadband provisioning
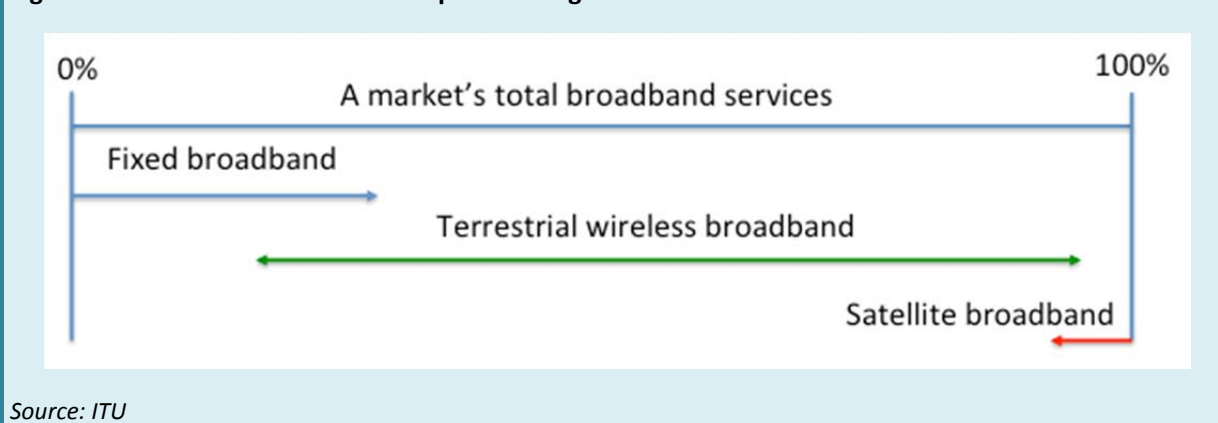
Source: ITU

It should be noted that to develop a comprehensive policy or masterplan would require further analysis and the inclusion of sections assessing fixed broadband services, notwithstanding that wireless technologies are currently, and are likely to be for the foreseeable the dominant technology for broadband connectivity in the Asia Pacific region.

1.3   Guidance to readers

While these Guidelines have been developed in a modular form, with a focus on group of the key issues in each section, analysis of these key issues cannot be done in isolation and all elements of the end to end eco-system need to be addressed in order to provide an optimal national wireless broadband masterplan. It should also be noted that throughout these Guidelines, a number of 'Masterplan Preparation Insights' have been included to provide practical advice to readers.

Masterplan Preparation Insight 1: An early assessment of the 'state of play' of a market's wireless broadband market is also critical in developing a national wireless broadband masterplan and determining the prioritised areas of intervention and/or policy focus for that masterplan.

1.4 Structure of the Guidelines

These Guidelines in dealing with the key elements shown in Figure 3 below comprise of nine main topics of analysis and recommendations. These are namely:

- broadband: global and regional context (section 2);
- state of play: overview and assessment of the market (section 3);
- ensuring legal and regulatory certainty (section 4);
- managing spectrum scarcity and ensuring harmonisation (section 5);
- technologies/innovations (section 6);
- stimulating demand: facilitating applications and content (section 7); and
- conclusions, way forward and suggested roadmaps (section 8).

Figure 3: Key inter-related elements of a wireless broadband masterplan
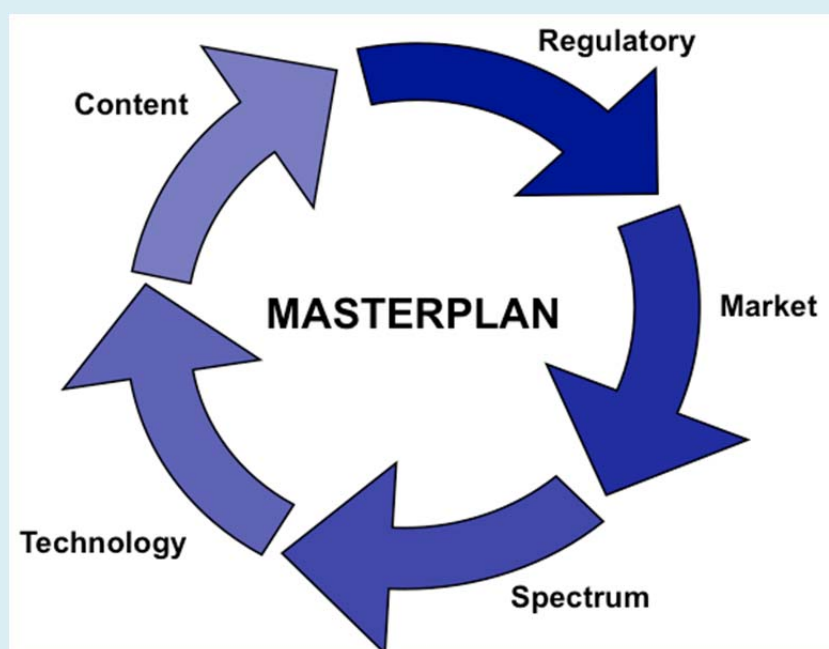
Source: ITU

2   Broadband – Global and regional context

> **Masterplan Preparation Insight 2:** While this section provides the global content for the preparation of a wireless broadband masterplan there is little debate about the importance of the availability of affordable and ubiquitous broadband services. The material is provided so that individual market wireless broadband masterplans properly frame the importance of broadband.

2.1   Overview

There is now almost a global consensus on the importance of broadband to a market's economic growth and the social interaction of citizens. The ability to access and provide data rich applications and content has become a pre-requisite for global trade and is fast becoming a necessary component of interaction between members of the public as well as government. While broadband connectivity is simply a means of accessing and providing data in as fast a manner as possible, its role has been identified as of high enough importance for it to warrant the characterisation of a 'human right'[2].

Aside from the practical benefits of broadband, such as greatly enhanced ease of accessing and providing data-rich content, numerous studies have documented the positive relationship between broadband access and national prosperity. A World Bank study emphasised the importance of broadband penetration for developing economies having concluded that every 10 per cent increase in broadband penetration provides a 1.38 per cent increase in GDP[3].

Broadband networks are able to deliver a host of applications and services that other mediums are simply not capable of. These services include:

- e-commerce;
- e-banking;
- e-government;
- e-education;
- paper-less work;
- improved education/training; and
- telemedicine/e-health.

Given these factors, broadband and improving broadband is now an international focus of development work including by the United Nations (UN), ITU and UNESCO[4]. This has resulted in broadband targets being incorporated with the UN's Millennium Development Goals and the prompting the creation of the Broadband Commission as a joint undertaking of ITU and UNESCO.

2.2   UN Millennium Development Goals

The UN Millennium Development Goals (MDGs) are comprised of eight specific targets for developing nations to achieve by 2015[5]. Telecommunications and broadband falls with the eighth goal of developing

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[2]   www.broadbandcommission.org/Documents/Broadband_Challenge.pdf

[3]   Christine Zhen-Wei Qiang and Carlo M. Rossotto with Kaoru Kimura, Chapter 3 Economic Impacts of Broadband, in World Bank, Information and Communication for Development 2009: Extending Reach and Increasing Impact (IC4D2009).

[4]   See www.un.org and www.unesco.org

[5]   These are namely: (1) Eradicate extreme poverty and hunger; (2) Achieve universal primary education; (3) Promote gender equality and empower women; (4) Reduce child mortality; (5) Improve maternal health; (6) Combat HIV / AIDS, malaria and other diseases; (7) Ensure environmental sustainability; and (8) Develop a global partnership for development.

a global partnership for development with sub-target 8(F) stating that 'In cooperation with the private sector, make available the benefits of new technologies, especially information and communications'.

Measured against the agreed indicators by the number of fixed telephones, mobile cellular subscriptions and the number of Internet users per 100 population, significant progress has been made globally (see Figure 4).

Figure 4:   Fixed telephone lines and mobile cellular subscriptions - Internet users - broadband subscriptions (per 100 inhabitants)
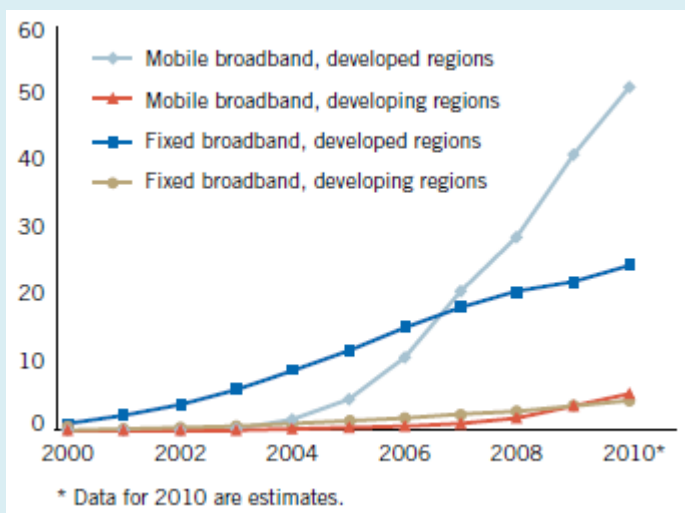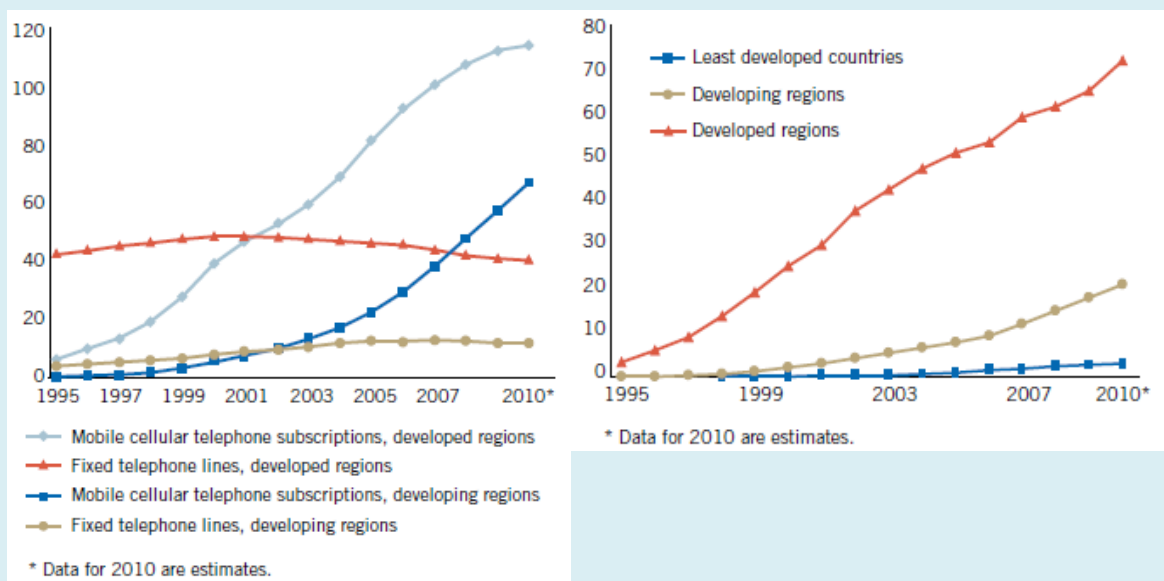
Source: UN Millennium Development Goals Report, telecommunications indicators 2011[6]

The Guideline goals are broadly consistent with targets 8F[7] of the MDGs and following the successful achievement of the masterplan goals, will be a significant factor in reducing the digital divide between emerging economies and their developed counterparts.

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6   http://mdgs.un.org/unsd/mdg/News.aspx?ArticleId=59

7   www.itu.int/ITU-D/ict/mdg/goals.html#g8

2.3   Broadband Commission

Until recently, broadband policy was largely the domain of national governments and the focus of regional initiatives. However, creation of the Broadband Commission for Digital Development in May 2010, a joint effort by ITU and UNESCO, is clear evidence of a shifting paradigm. The Commission was set up with the aim of engaging in 'advocacy and high-level thought leadership to demonstrate that broadband networks:

- are basic infrastructure in a modern society - just like roads, electricity or water;
- are uniquely powerful tools for accelerating progress towards the MDGs;
- are remarkably cost-effective and offer impressive returns-on-investment (ROI) in both developed and developing economies alike;
- underpin all industrial sectors and are increasingly the foundation of public services and social progress;
- need to be promoted by governments in joint partnership with industry, in order to reap the full benefits of broadband networks and services.[8]

Within the context of the masterplan, these conclusions and regulatory considerations are important as they provide both guidance and clarity. With respect to these considerations, the masterplan will be consistent with the focus of the Commission and its recommendations/policies.

The Commission debated the possible way of defining broadband and conceded that delineations such as upstream/downstream speeds are arguably inadequate due to rapid technological advances. Instead, they believed that focus on core concepts, such as always-on service (the user isn't required to make a new connection to the server each time) and high capacity (capable of carrying lots of data per second) would be preferred alternatives as they would not be as constraining nor subject to frequent revision[9].

In the report *Broadband: A Platform for Progress*[10], the Commission discussed a range of issues for governments to consider when deploying broadband networks. Conclusions that emerged from the report included, *inter alia*:

- infrastructure policy should be goal oriented and not focused on particular technologies;
- pricing or other access barriers should be removed;
- associations between infrastructure and a type of service should be avoided;
- infrastructure sharing is beneficial and should be encouraged; and
- fibre-optic networks are likely the preferred backhaul network solution, but depending on national geography / topology, may need to be complimented by wireless infrastructure[11].

The report identifies a number of considerations to be taken into account by governments and regulators in developing economies that are grappling with the challenges associated with increased broadband access. There are a number of areas in this regard that are of particular relevance to this wireless broadband masterplan. These are summarised in Table 1.

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[8]   See www.broadbandcommission.org

[9]   See www.broadbandcommission.org/Reports/Report_2_Executive_Summary.pdf

[10]   www.broadbandcommission.org/Reports/Report_2.pdf

[11]   *Ibid.*

Table 1: Broadband challenges

No.	Issue	Details
1.	Attracting investment in broadband	This may include: • reducing investment / regulatory barriers; • encourage infrastructure sharing; • introducing innovative spectrum management mechanisms; and • amend regulatory frameworks to eliminate discriminatory rules that favour one company / industry over another.
2.	Addressing persistent gaps in the market	It is recognised that in cases where infrastructure deployment is highly expensive or impractical, the government may need to be proactive in addressing bottlenecks. Authorities also need to maintain cognisance over possible adverse implications of hyper-competition, which may dampen sector investment. The universal service fund may pose challenges as changing definitions of services may require the government to address issues of which entities are required to contribute.
3.	Funding broadband	The Commission stated that true access gap (a shortfall between market-based measures and universal access) may need to be addressed in circumstances where there is evidence that regulatory incentives and lower-cost network alternatives are not enough to encourage supply in certain instances. Governments may address these issues vis-à-vis remedies relating to issuing special licences in defined locations, funding local community initiatives, providing direct financial support to operators or mandating the deployment of broadband access networks.[12]

The Commission endorsed the Broadband Challenge in October 2011 whereby broadband connectivity was recognised as a human right and a crucial driving force behind economic growth. Importantly, governments were urged to adopt policy platforms that would facilitate broadband network deployment and service uptake. Member States were advised against retaining policies that would limit market entry and tax ICT services unnecessarily. Governments were encouraged to promote coordinated standards of interoperability and achieve maximum utility for scare radio spectrum. It was seen as necessary to review existing regulatory and legislative frameworks, many of which reflect outmoded 20th century models and ensure that information flows are free and unhindered[13].

The Commission adopted a set of four broadband targets to be achieved by 2015:

i. all countries should have a national broadband plan / strategy or include broadband in their universal access / service definitions;

ii. entry level broadband services should be made affordable in developing countries through adequate regulation and market forces (for example, amounting to less than 5 per cent of average monthly income).;

iii. forty per cent of households in developing countries should have Internet access; and

iv. Internet user penetration should reach 60 per cent worldwide, 50 per cent in developing countries and 15 per cent in least developed countries.

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[12] *Ibid*

[13] www.broadbandcommission.org/Documents/Broadband_Challenge.pdf

2.4   Regional initiatives

> **Masterplan Preparation Insight 3:** Regional commitments can be important as a driver of change and can assist in framing individual country masterplan targets and policy settings.

In the Asia Pacific region, there are significant regional initiatives in relation to broadband and ICT policies which frame the debate in relation to wireless broadband services depending on a country's membership of a regional organisation. Regional groupings include the Association of Southeast Asian Nations (ASEAN) in South East Asia[14], the South Asian Association for Regional Cooperation (SAARC) in South Asia, and the Pacific Islands Forum[15].

2.4.1   ASEAN 2015 ICT Masterplan

All ASEAN members have committed to the ASEAN ICT Masterplan 2015. The masterplan is a broad, overarching policy-framework that is intended to guide ASEAN Member State ICT development over the next five years. The policy has consequences for any wireless broadband masterplan adopted by signatory states, as the plan will need to evolve within the context of the broader ICT mosaic and strive for consistency.

Members have committed to a single strategic vision of enabling ASEAN's social and economic integration and facilitate the transformation into a single market. By 2015, the following key outcomes have been set:

      i.   ICT as an engine of growth for ASEAN countries;

      ii.   recognition for ASEAN as a global ICT hub;

      iii.   enhanced quality of life for peoples of ASEAN; and

      iv.   contribution toward ASEAN integration.

Box 1 elaborates on four of the six areas of the ASEAN ICT Masterplan 2015 which have direct implications for the development of a wireless broadband masterplan in any ASEAN market.[16]

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[14]   Refer to www.aseansec.org

[15]   Refer to www.forumsec.org

[16]   www.aseansec.org/documents/ASEAN%20ICT%20Masterplan%202015.pdf

Box 1: ASEAN ICT Masterplan 2015

-----------Strategic Thrusts for ICT Policy-----------

I. **Economic Transformation**

Members are to create a conducive business environment that helps to attract trade, investment and entrepreneurship in the ICT sector. Leveraged investment in ICT will consequently be a driving force for growth in other key economic sectors.

Creating an enabling business environment necessitates the development of a framework to facilitate transparent and harmonised ICT regulations. Within the context of developing a wireless broadband masterplan, this action is significant as it will require the regulatory authorities of pilot nations to be cognisant of the regulatory practices in neighbouring states and implement new policies / regulations in such a way so as to maintain consistency with ASEAN nations.

II. **People Engagement and Empowerment**

A focus on people engagement and empowerment is intended to devote resources to the improvement of quality of life for ASEAN people through affordable ICT – especially in low income / remote areas where ICT access is considered to be a luxury. Member States have committed to ensuring access to affordable and seamless e-services, content and applications. This is to take the form of providing incentives / grants to promote such services. The value of wireless broadband lays in part through its ability to seamlessly access such services and applications in a convenient and highly practical manner. The promotion of these services will enhance the attractiveness for wireless broadband technology for users and operators alike.

III. **Infrastructure Development**

Infrastructure development is a key component of ASEAN's ICT policy and is recognised as necessary for the successful implementation of the other strategic thrusts. Member States have committed to establishing an ASEAN Broadband Corridor. This will be achieved through a number of means including:

i.   identifying and developing locations in ASEAN Member States which offer quality broadband connectivity;

ii.   enabling seamless usage of broadband services and application across the ASEAN region to improve connectivity and services; and

iii. promoting the diversity of international connectivity among ASEAN Member States.

An ASEAN Internet Exchange Network has also been scheduled for completion. This will be achieved by establishing a regulator / operator forum to develop a platform to enable intra-ASEAN internet traffic and facilitating peering amongst ASEAN internet access providers to reduce costs and improve latency.

IV. **Bridging the Digital Divide**

Another important strategic thrust relates to the acknowledgment of imbalance of development amongst ASEAN Member States. This therefore necessitates a range of initiatives to be adopted that are focused on closing this development gap. Member States have agreed to review their USO / similar policies with a view towards including IT components and training as a part of USO funding. Furthermore, Members need to ensure that ICT infrastructure covered under USO is broadband Internet capable. This will likely have positive implications for policies geared towards the deployment of mobile broadband infrastructure as it opens the door to a new avenue of funding.

2.4.2   SAARC ICT Initiative

Nepal, alongside other SAARC Members (Afghanistan, Bangladesh, Bhutan, India, Pakistan and Sri Lanka), is committed to a regional ICT policy aimed at increasing penetration, quality and harmonisation of ICT services.

A 'Plan of Action' for telecommunications services has evolved over three SAARC conferences in 1998, 2004 and 2008. The following aspirational goals and objectives were formulated:

- "*To promote cooperation in the enhancement of telecommunication links and utilization of information technologies within the SAARC region;*
- *To minimize disparities within and among Member States in the telecommunications field;*
- *To harness telecommunication technology for the social and economic upliftment of the region through infrastructure development by optimal sharing of available resources and enhanced cooperation in technology transfer, standardization and human resource development; and*
- *To evolve a coordinated approach on issues of common concern in international telecommunications fora.*"[17]

At subsequent SAARC conferences, Member States committed to implementing fellowships and training programmes for telecommunications human resources staff as well as R&D and adopting uniformly applicable low tariffs for intra-SAAR phone calls. In addition, Member States were directed to 'give priority to universal access' and 'cooperate in the development of plans and for the utilization of ICT in e-commerce, health care education and other areas by the exchange of information and expertise'.

In 2009, a meeting of the Working Group on Telecommunications and Information and Communications Technology agreed in principle to a proposal regarding upgrading of national and regional telecommunications infrastructure.

The 18-point SAARC Plan of Action on Information and Media (PAIM) was formulated to achieve the ICT and media objectives that Member States agreed to in the 1998 Dhaka conference. These objectives (revised in 2004) included, inter alia:

- reducing rates for media transmission and information materials;
- ensuring the free flow of information; and
- enhancing the exchange of data through the Internet.

It is worth noting that the achievement of higher broadband penetration will facilitate the meeting of PAIM targets.

2.4.3   Pacific Islands Forum

The Pacific Islands Forum[18], comprising countries and territories of the Pacific region, seeks to enhance economic growth, political governance and integration between member nations.

Given the potential of broadband to provide economic growth, as well as being an important means of connecting people with government, broadband policy has been a significant area of discussion[19].

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[17]   www.saarc-sec.org/areaofcooperation/cat-detail.php?cat_id=56

[18]   www.forumseg.org

[19]   Many countries in the Pacific region share similar characteristics, including population, geography and export markets. They also face similar challenges, including interconnection over vast ocean distances, as well as key regulatory issues such as infrastructure sharing and spectrum management. However, different countries are also at different stages of ICT development, and so a flexible strategic plan is required. Wireless broadband can be an important tool for the promotion of cultural and ethnic diversity. At the same time, effective broadband policy also requires a coordinated approach, and interconnectivity is essential for securing both higher speeds and a deeper market for content and services.

The Pacific Plan, endorsed at the Pacific Leaders Forum in 2004, identified ICT as a priority for Pacific Island countries.

In 2000, the forum approved the *Pacific Islands ICT Policy and Strategic Plan*[20], which provided a framework for the development of ICT policies at the national level. For each policy, the plan provides a set of recommended activities along with suggested performance indicators, and recommended the introduction of draft model legislation and regulations based on international experience, and the strengthening of national regulators. It committed to technology-neutral use of spectrum and open and non-discriminatory access to public networks where appropriate. Importantly, the Plan called for the investigation of high-speed national ICT networks, including through the use of submarine cables and emerging technologies.

In 2005, the forum released the *Pacific Regional Digital Strategy*[21] , which focuses on improving access, encouraging investment through more effective regulation, and removing gaps in ICT knowledge. The digital strategy recognises the importance of ICT for the development of human capital, including literacy rates and education. It aims to encourage greater private sector investment in infrastructure, promote competitive markets to reduce costs, and encourage local content. While the digital strategy provides the principles and strategy for effective ICT, the implementation is left to individual members, which must develop their own plans for their communities in consultation with stakeholders.

Since the introduction of the digital strategy, important developments have taken place, including further liberalisation, greater international connectivity and a reduction in the digital divide. However, there remain gaps in outcomes across member countries. In 2010 the forum conducted a review of the digital strategy in two parts, with Part A addressing technological capacity, and Part B providing recommendations to assist with a revised digital strategy. In particular the review looked at government delivery of health and education services, the state of broadcasting and the cost of Internet access, including international bandwidth.

The Pacific Islands Forum is continuing its development of the digital strategy, and it is understood that it is to be a living document that reflects the progress made by the region as a whole while addressing the unique challenges faced by different countries. As such it is a strategy document that ought by factored in Pacific Islands in the development of their wireless broadband masterplans.

2.5   ITU ICT development index and link to growth

According to ITU analysis, there is a strong correlation between the development and maturity of a country's ICT infrastructure and economic growth. This relationship is even more prominent in emerging economies. The ICT development index (IDI) is intended to provide insight into the level and evolution over time of national ICT development, progress in ICT development, the digital divide and development potential of ICT. It represents an amalgamation of data measuring ICT access, usage and skills.

Improvement in mobile cellular penetration has positive implications for the future of wireless broadband and achieving key wireless broadband masterplan targets/priorities. It also generates much forward momentum in place so as to expedite the aspects of the masterplan and set even loftier benchmarks. It should also be noted that the fulfilment of masterplan priorities would undoubtedly improve a country's IDI ranking which would have beneficial implications for national growth and its regional positioning.

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[20]

www.forumsec.org/resources/uploads/attachments/documents/Pacific%20Islands%20ICT%20Policy%20and%20Strategic%20Plan%20(PIIPP)%202002.pdf

[21]   See www.forumsec.org/resources/uploads/attachments/documents/Pacific%20Regional%20Digital%20Strategy.pdf

2.6   Other global development trends in broadband and policy regulation

In recent years, several key trends have emerged with respect to broadband policy and regulation, which also need to be taken account when preparing a wireless broadband masterplan. Governments around the globe have become increasingly cognisant about the importance of high-speed networks and their link to economic growth. As a consequence, there has been a substantial increase in government participation and intervention within the ICT sector. Broadly speaking, this intervention consists of:

- the encouragement of private sector participation via improved access arrangements, simplified licensing and deregulation;
- the development of national broadband plans/policies;
- financial support in the form of subsidies, tax breaks, grants and loan assistance;
- expanding the scope of universal service obligations (USO) to encompass broadband services;
- updating regulatory regimes to take into account the convergence of media and communications; and
- redirecting universal service funds (USFs) to enable broadband in rural/isolated/low-income areas.

In addition, regulators are coming to terms with the need to prepare for a material increase in the demand for scarce spectrum. Global spectrum management arrangements are evolving to meet changing patterns of use and demand for spectrum. Following a trend that began in Australia, Japan, the United States and New Zealand, steps are being taken to reduce the involvement of government and let market mechanisms govern the allocation and destination of use of spectrum including:

- allocating spectrum through price-based selection processes – especially auctions – or alternative proxy methods to impose apparatus charges which reflect the value of the spectrum;
- the owners of spectrum rights are increasingly free to decide which technology to use and which services to provide with it;
- in line with spectrum liberalization, the introduction of spectrum trading in some markets is allowing spectrum rights to be allocated via market mechanisms to the users that value it the most; and
- the increasing prevalence of spectrum leasing arrangements which allows a spectrum owner to sub-lease, part or all of their allocated frequencies.

3   State of play: Overview and assessment of the market

Masterplan Preparation Insight 4: This assessment is critical and along with the legal and regulatory review, the most country specific element of the preparation of the wireless broadband masterplan.

After gaining an appreciation of the context of global and regional broadband the second step in order to formulate a quality wireless broadband masterplan is to undertake detailed analysis of both the country itself and of the state of play in the country's wireless broadband market. Some of the key questions to be asked are detailed in Box 2.

Box 2: State of Play: Overview of the country and the wireless broadband market

1.   Country overview:
(a) Demographics
-    Country demographics?
-    How can the country be characterised? Namely, is it developed, emerging, or SIDS (Small Island Developing State)?
-    Does it have an agriculture, manufacturing or service based economy?

(b) Geography
-    What are the general geographic characteristics of the country?
-    Is the country mountainous or flat? Large or small?
-    What is the area of the country and what is its population density?
-    Is the country's population distributed thinly or clustered in certain places?

(c) Economy
-    What are the major sectors of the country's economy?
-    What are the total outputs of the different sectors as a % of output as a whole?
-    What is the average income in the country?
-    What is the country's GDP per capita?

(d) Government
-    What is the government policy in relation to ICT and wireless broadband?

2.   Market overview:
(a) Overview
-    What is the total value of the telecommunications sector in the country?
-    What percentage of this revenue is based on mobile access?
-    How many ICT providers are there in the market?
-    What is the country's backhaul capacity? How widespread is fibre?
-    What is the country's international bandwidth capacity?

(b) Fixed services
-    How many fixed line operators are in the country? What is the fixed teledensity?
-    How much competition is there from fixed line operators in the broadband area?
-    What is the ratio between mobile broadband to fixed broadband subscriptions?

(c) Mobile services
-    What is the country's mobile teledensity?
-    What technologies are used for mobile services? For example, GSM, W/CDMA, etc.
-    What is the level of wireless broadband penetration?

(d) Market structure
-    Are fixed or mobile services more common in the country?
-    What are the growth rates of the two types of services?
-    How many licences or providers are there currently in the mobile market?
-    Who has these licences and what is their relative market power?
-    What are the current retail pricing structures in the market?
-    Are these prices regulated at all?

(e) Policy initiatives and objectives
-    What are the current sector policies/objectives? Is there a regional ICT masterplan?

These questions aim to determine the state of play of the telecommunications sector in the country, and to give context to the formulation of a wireless broadband masterplan both in terms of the current market situation and in terms of the specific circumstances of the country as a whole. This information is crucial both to developing a policy and to the actual application of that policy in the future.

Information on the current market is important because it provides an indication as to the current level of development of the sector, as well as indicating where investment and input is needed. In locations where access to wireless services is low investment is needed in infrastructure. If there is low service penetration nationwide then investment should begin in areas of highest population and revenues and experience

gained may be used to deploy services to more regional and/or rural areas. Alternatively, government may wish to concentrate any subsidies on rural or low penetration areas.

The population demographics of the country are also important for determining the most effective way to ensure that services are provided as efficiently as possible. In countries which have significant rural populations which are geographically distant from population centres, satellite based technology is more likely to be effective than terrestrial wireless services.

The questions above aim to provide enough information to ensure that these decisions can be made with appropriate context and with knowledge of the current state of play. This helps optimise policy and regulatory settings, reduce investment risk, improve technology selection etc. The answers/information should also aid in ensuring that the wireless broadband masterplan which is developed can be implemented effectively.

4 Ensuring legal and regulatory certainty for wireless broadband

4.1 Introduction

Ensuring that there is legal and regulatory certainty for market participants to invest in infrastructure, services and content related to wireless broadband service delivery is a key part of any successful wireless broadband masterplan. Arguably, it is the most important and certainly the most difficult to achieve. Optimising regulatory frameworks for wireless broadband involve reconciling and accommodating many stakeholders has shown in in Figure 5.

Figure 5: Key stakeholders in the telecommunication sector
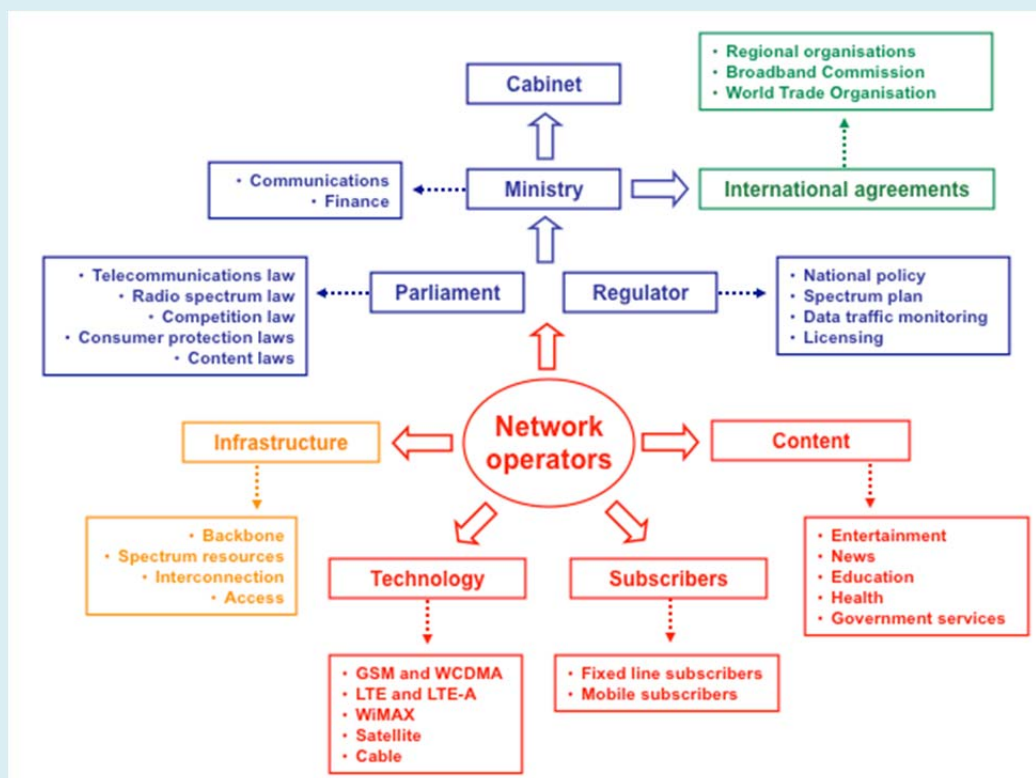
Source: Windsor Place Consulting, 2010

> **Masterplan Preparation Insight 5:** A wireless broadband masterplan – along with other sector policies should inform and create a shared set of goals for all market participants.

While an exploration of all applicable regulatory issues is beyond the scope of these Guidelines and is the subject of many other ITU publications, the key issues which need to be assessed in relation to legal and regulatory issues are detailed in Box 3.

> **Box 3: Selection of main legal and regulatory issues in relation to wireless broadband**
> • Is the sector legislation modern and comprehensive embracing convergence, technology neutrality etc.?
> • Is the sector legislation and applicable regulatory framework supportive of competition and attracting new investment? Does it provide a high degree of regulatory certainty?
> • Is there an effective and unified licensing regime?
> • Are other supportive regulatory frameworks for wireless broadband in place – including infrastructure sharing?
> • Are competitive safeguards needed in relation to spectrum capping, in relation to mobile virtual network operators (MVNOs) etc.?
> • What other regulatory issues are important to facilitate wireless broadband?

For this section of the Guidelines the discussion is necessarily confined to:

- i. assessing the adequacy of legislation and the content of new sector legislation (section 4.2);
- ii. attracting new investment and competition to promote wireless broadband (section 4.3);
- iii. migration from a legacy model of spectrum management to a more flexible use model (section 4.4);
- iv. permitting technology neutral licensing and spectrum use (section 4.5);
- v. facilitating Infrastructure sharing (section 4.6);
- vi. promoting wireless sector competition by instituting spectrum caps and mandated MVNO models (section 4.7); and
- vii. other key policy and regulatory issues. (section 4.8).

4.2   Assessing the adequacy of legislation and the content of new sector legislation

> **Masterplan Preparation Insight 6:** Undertaking a legislative review as part of the masterplan process is critical for emerging markets but is also of benefit in all markets.

4.2.1   Legislative review

A review of current telecommunications legislation and related instruments should be conducted to determine the adequacy of the existing regulatory framework. It is particularly important for developing nations to update legislation where it has become antiquated in order to create an environment that is conducive to the emergence of a modern communications system.

The importance of securing a modern legislative and regulatory framework will only increase as developing countries continue to experience economic growth and integration with regional and global counterparts. It is arguable that the need for change is pressing. Where legislation has become out-dated a new framework should be introduced that represents global best practice and that can best facilitate the growth in telecommunications services.

4.2.2   The content of new legislation (if necessary)

While a draft of the new sector legislation has been prepared it is worthwhile in these Guidelines to outline the recommended form and content of a new statutory framework. For developing countries there is also a need for the legislation to provide for the creation of a more independent telecommunications department (either the existing agency or a successor organisation) as this will improve regulatory certainty and be consistent with global best practice. Broadly speaking, the law should address at least the following areas:

- licensing;
- frequency / spectrum management;
- technical standards;
- consumer protection;
- competitive practices;
- universal service;
- access and interconnection / infrastructure sharing; and
- transitional arrangements.

Licensing

Licensing is one of the core elements of a regulatory framework and is one of the most important instruments which governments and regulators can employ in the context of the communications sector and its reform. Licensing is integrally tied to the structure of the telecommunications markets, the degree of competition between them, the revenues earned by governments in opening markets and ultimately, the efficiency of the supply of telecommunications services to the public. It is therefore important to ensure that a workable licensing framework is in place. This is because a robust, forward-looking and transparent licensing regime is critical for the long-term success of the country's communications sector.

A telecommunication licence may be defined as an official authorisation to provide services and/or operate networks. It also can be a regulatory "code" or otherwise a scheme that defines the terms and conditions under which the licensee may operate. Licences usually also describe the rights and obligations of the provider. In short, the licensing process controls both entry into a communication market and, often, the behaviour of the licensee once it enters and operates within that market. The introduction of a standard licensing framework is a key step in an overall restructuring of operator licences in order to reflect the technical and market realities of convergence.

A unified licensing regime would simplify the licensing procedure, allow service providers to use any technology, ensure flexibility and efficient use of resources. In addition, unified licensing framework removes arbitrary and artificial distinctions which are not technically supported, promotes sector competition and sector convergence. Assuming the national legislative framework facilitates the implementation of a unified licensing regime, refer to Appendix A for the draft telecommunication licence.

Frequency / spectrum management

Given the current central role of wireless services in the telecommunication environment and the fact that with increased voice and wireless broadband penetration wireless services will only increase in importance, a transparent and effective spectrum management framework is absolutely essential.

Regulatory agencies should be responsible for all aspects of spectrum management, including space services. A radio-licence should be necessary to use spectrum in those frequency bands allocated to specific radio services (i.e. mobile telephony and wireless broadband).

Technical standards

In addition to licence conditions, regulators should set technical conditions for the operation of network facilities, services and devices to ensure harmony and compatibility with regional and/or global standards.

Key functions and responsibilities of the relevant government ministry concerning technical standards should include:

- co-ordination, preparation and approval of technical telecommunication standards;
- co-ordination and communication with domestic and foreign organisations and institutions concerning technical telecommunications standards;
- developing and adopting a process for type approval of terminal equipment;
- testing the radiation of industrial, medical and scientific equipment and licensing for approval;
- establishing technical committees to facilitate the development of technical standards; and
- maintaining information on standards activities and a list of approved national standards.

Consumer protection

The legislation needs to mitigate issues relating to over-charging, poor quality service and the sharing of confidential information. These problems typically emerge to the detriment of end-users in situations where a telecommunications market is experiencing fast and sustained growth.

Licensees should submit tariff schemes to the regulator. In addition, subject to ministerial approval, the regulator ought to determine suitable consumer standards that shall apply to network service licences.

Competitive practices

If the government decides to allow the entry of new operators into a domestic market then new competition rules and/or regulations must be implemented in order to safeguard end-users and lay the foundations for an efficient and dynamic industry. Anti-competitive conduct for example, may result in the refusal to provide interconnection or access to infrastructure, discriminatory pricing or price fixing. The legislation optimally would prohibit anti-competitive conduct by licensees and the abuse of market power. The regulator should be able to issue competition rules and be able to direct the offender to cease the said conduct.

Universal service

In the past, universal service obligations have typically been applied to incumbent operators providing fixed-line telephony. In the case of many developing countries, such an obligation is unlikely to facilitate further investment or an increase of teledensity. A universal service/coverage obligation should apply to service and facility licensees in order to encourage Capex and investment. When appropriate, the obligation could be expanded to encompass wireless broadband access.

Access and interconnection / infrastructure sharing

Interconnection/access between networks is essential to effective competition and the delivery of quality services to end-users. International experience shows that interconnection charges constitute a major portion of the operating costs of new entrants. As such, the effectiveness of new entrants in terms of competitive edge and commercial viability are very sensitive to the level of interconnection charges.

Interconnection policy is driven by the achievement of fair and equitable arrangements between operators. Access and interconnection shall be provided on an equitable and non-discriminatory basis and not be of a lower technical standard and quality relative to the licensee's own network facilities and services. The regulator should be mandated to approve any interconnection / access agreement between licensees.

Transitional arrangements

In the event that licences were issued prior to the new law coming into force, provision will be made to accommodate such arrangements made under the previous laws. This will aid clarity and reduce business uncertainty.

4.3   Attracting new investment and competition to promote wireless broadband

Masterplan Preparation Insight 7: The importance of this issue in an individual country masterplan depends on the outcome of the market review done in accordance with section 3.

4.3.1   Overview

Given the well-established economic benefits of increased telecommunications and broadband penetration, there is a compelling case for nations with uncompetitive telecommunication markets to quickly increase telephone penetration to support economic growth. Fully or partially state-owned enterprises are capital constrained and, even with innovative models, are highly unlikely to be able to commit to the substantial capital expenditure, which is estimated to be necessary in order to achieve acceptable levels of penetration.

While beyond the scope of this document, a two-stage process for introducing competition is suggested. This process would also have the effect of generating significant one off and on-going revenues for national budgets and should be endorsed by governments.

The key challenge is to design a process that will see the viable entry of additional licensees into the market that will be able to compete with incumbents for the provision of both mobile voice and wireless broadband services and the securing of significant one off and on-going fees for the government if this is also a policy goal. Part of the monies raised could be used to provide state-owned (or partially state-owned) enterprises with a significant capital injection so that they can quickly grow in competition with the new entrants.

4.3.2   Facilitation of new entrants

Where there is assessed to be a lack of competition in national licensing that is detrimental to the growth of wireless broadband, measures to encourage new entrants into the market should be considered by the government and the regulator. Where a market contains one operator with a dominant position or a couple of operators with significant market power, it is arguably not likely to produce the optimal outcomes for consumers going forward. In the absence of appropriate competition laws and policy, it also makes it difficult for potential new operators to gain a foothold in the market.

As such, consideration should be given to facilitating one or more new entrants to accelerate wireless broadband services. If the new entrants are willing to risk their capital to invest in infrastructure, this should be encouraged. A possible new entrant would also increase competitive tension if new cellular spectrum (e.g. 700 or 2600 MHz) was to be auctioned going forward.

A suggested competition and spectrum allocation strategy to underpin voice and wireless broadband deployment (and to maximise government revenues) is detailed in Appendix B: Outline of recommended process to introduce sector competition and attract new investment. Introducing additional competition into mobile service markets is a two-stage process as Appendix B demonstrates.

4.4   Migration from a legacy model of spectrum management to a more flexible use model

Globally there is a major transition occurring between the legacy model of spectrum management and a liberalised model. It is recommended that countries considering wireless broadband masterplans should embrace such changes and manage them. This means a flexible use model with spectrum trading rights and mechanisms which allocate spectrum to their best use. This is depicted in Figure 6. In this context part of the challenge is managing the transition.

Masterplan Preparation Insight 8: To facilitate spectrum trading it is likely to be necessary to promulgate a regulation or similar instrument which provides for a spectrum grid. Based on the spectrum grid, users can define the boundaries of the spectrum lots for trading, leasing etc. and the licensing areas. The spectrum grid comprises of concepts of spectrum grid cells and spectrum grid unit and can cover the entire country and/or cells based on fixed geographical location on the basis of minimum and maximum longitude and latitude coordinates. In relation to spectrum leasing, the proposed spectrum lease must be greater than a single spectrum grid unit, and is defined in terms of whole numbers of spectrum grid units. For example, lots of spectrum space is defined for spectrum leasing. A spectrum lease area is defined by reference to the spectrum grid. When a lease is made, the leased spectrum grid unit may be aggregated into the lessee's existing spectrum space to form new licence areas.

Figure 6: Transition to market based liberalized spectrum management models
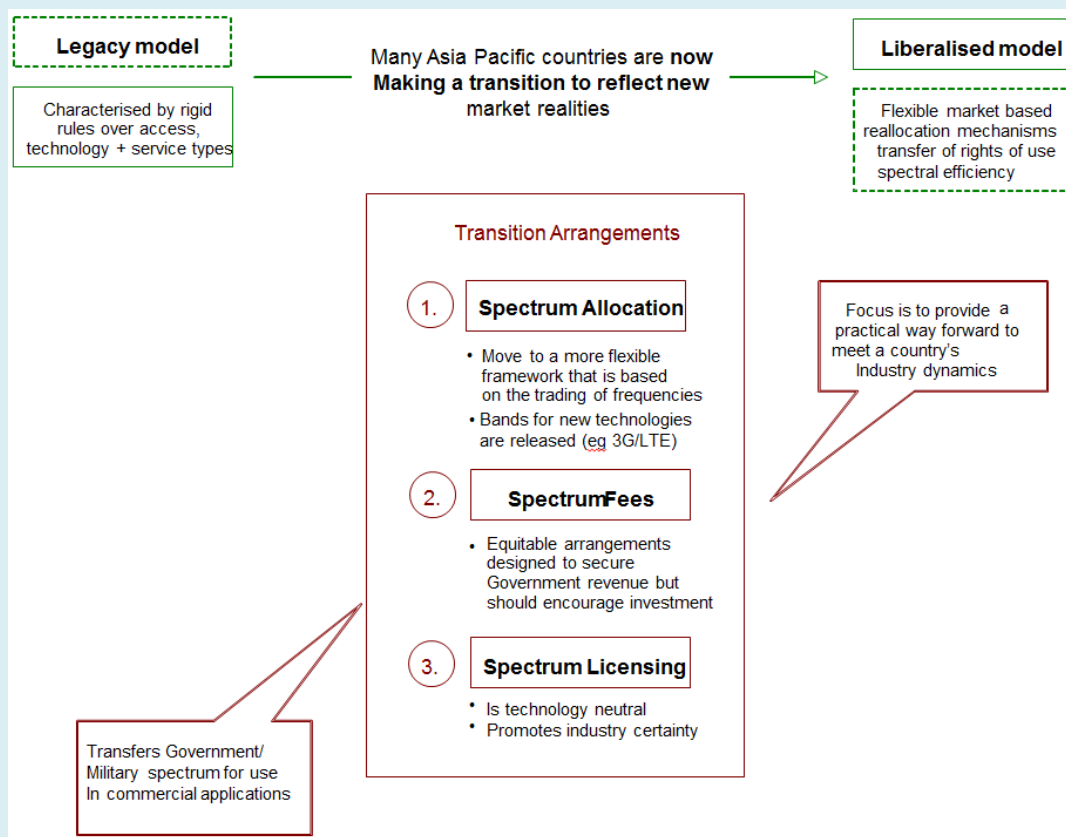
Source: Windsor Place Consulting, 2010

It is important that the country regulators embrace a strong set of spectrum management principles which informs in its dealings with industry, consumers and other internal stakeholders. In recognising that spectrum is a scarce resource that needs to be managed effectively and efficiently, the delegates to the ITU Global Symposium for Regulators (GSR)[22] drafted a set of best practice guidelines for spectrum management to promote broadband access. This ten point set of guidelines continues the tradition of best practices agreed to at the GSR conferences in 2003 and 2004 on promotion of universal access, and low cost broadband services respectively. A summary of the 2005 GSR Guidelines are set out as a reference point in Table 2.

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[22] www.itu.int/ITU-D/treg/Events/Seminars/GSR/index.html

Table 2: ITU GSR best practice guidelines for spectrum management

No	Guideline objectives	Key Provisions
1.	Facilitate the deployment of innovative broadband services and technologies	• Reduce unnecessary restrictions on spectrum use • Adopt harmonised frequency plans defined by ITU-R recommendations[23] • Reduce or remove regulatory barriers to market entry • Ensure operators have access to as wide a choice as possible for spectrum
2.	Promote transparent and non-discriminatory spectrum management policies	• Consult widely and publicly • Implement stable decision making processes • Publish forecasts of spectrum usage and allocation needs • Publish frequency allocation plans and overview of assigned spectrum • Clearly define and implement stable and predictable spectrum authorisation rules and decision-making processes and procedures
3.	Embrace technology neutrality	• Facilitate spectrum use for fixed and mobile services • Provide guidelines to mitigate inter-operator interference • Adapt to technological convergence and avoid picking winners
4.	Adopt flexible use measures for wireless broadband services	• Avoid onerous rollout and coverage obligations • Licence conditions that allow operators to provide a full range of converged services • Provide incentives for smaller new operators to deploy infrastructure at low cost • Adopt lighter regulation for rural and isolated areas • Allow secondary spectrum trading • Promote spectrum sharing
5.	Ensure affordability	• Set reasonable spectrum fees • Design tender or auction processes to ensure affordability of services
6.	Optimise spectrum availability	• Facilitate the effective and timely access to spectrum • Spectrum pricing should not be pushed up due to restrictive supply • Accommodate new and emerging technologies
7.	Manage spectrum efficiently	• Ensure reliance on market forces, economic incentives and technical innovation • Allocate spectrum in an economically efficient manner • Promote and encourage usage of spectrum efficient technologies
8.	Ensure a level playing field	• Prevent spectrum hoarding: regulators should set a maximum limit to the amount of spectrum one operator may obtain

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[23] Refer to the list of ITU-R Recommendations on IMT at www.itu.int/ITU-R/index.asp?category=information&rlink=imt-advanced-rec&lang=en. Harmonised frequency plans are contained in ITU-R Recommendation M.1036-4 (March 2012).

No	Guideline objectives	Key Provisions
9.	Harmonise regional and international standards and practices	• Reflect global technical and security standards in national arrangements • Ensure inter-operability for global roaming • Implement policies and allocations that are consistent with regional and global best practice and standards
10.	Adopt a broad approach to promote access	• Introduce supporting regulatory measures such as competitive safeguards, open access and universal service incentives • Lower or remove import duties on broadband wireless access equipment • Coordinate spectrum management policy and practice with other regulatory instruments (i.e. competition and trade policy, universal service measures etc.)

Source: ITU, GSR 2005 Best Practice Guidelines for Spectrum Management to Promote Broadband Access, www.itu.int/bestpractices

4.5 Permitting technology neutral licensing and spectrum use

Masterplan Preparation Insight 9: Allowing network operators to use the latest, most efficient and cost effective technology is compelling at many levels. Arbitrary policy and regulatory restrictions which preclude such flexible use is not in the public interest.

The core basis of a technology neutral spectrum is that any service should be provided through any kind of technology in any frequency band, and the use of spectrum can be changed at any time. That is, the actual use of the spectrum is not specified. For example, in Australia, spectrum licences can be used with any technology and for any use so long as emission limits are observed. Examples include W-CDMA utilising the 900 MHz (Box 4) and LTE utilising the 1800 MHz bands (Figure 7).

Box 4: W-CDMA deployment at 900 MHz

According to the GSA as at 9 February 2012 there are 40 commercial UMTS900 networks (HSPA or HSPA+) launched in the 900 MHz spectrum. These include at least 29 countries with UMTS900 deployments including Australia, Bulgaria, Croatia, Estonia, Faroe Islands, Finland, France, Germany, Ghana, Greenland, Hong Kong (China), Iceland, Latvia, New Zealand, Poland, Qatar, Romania, Russia, Slovenia, South Africa, Spain, Switzerland, United Kingdom, Ukraine and Venezuela.

In practice, a number of issues arise the key one being interference problems. The technical framework for the band which helps to define the licence impose constraints on licensees which effect their usage choices in that spectrum licences are therefore not entirely technology neutral but are designed with ITU allocations and available technologies in mind.

Basically, these types of licences authorise the use of spectrum whereby licences are free to use any device and technology within their spectrum provided that such devices comply with the conditions of the licences and guidelines established for the corresponding bands. Unfortunately, use of frequency bands is often not the same around the world. Also frequency bands are subject to replanning in the longer term.

Figure 7: LTE-FDD deployment at 1800 MHz[24]
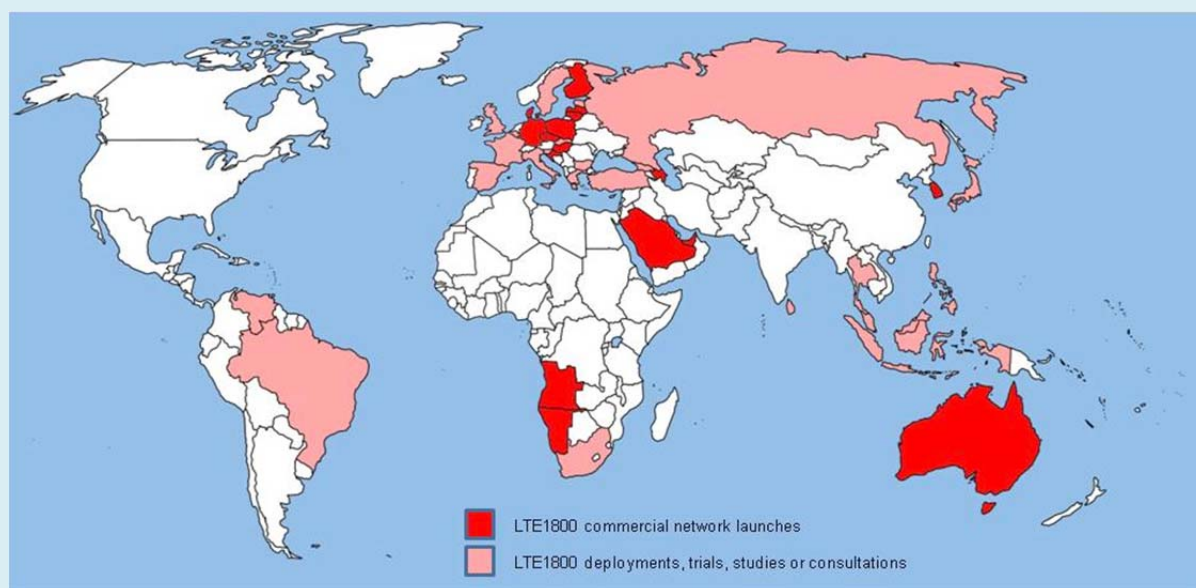
Source: GSA, Evolution to LTE report, 11 July 2012. Available at www.gsacom.com

Technology neutral licences were pioneered in New Zealand with the system of management rights and in Australia, with the introduction of spectrum licences. Since then:

- in the United Kingdom, Ofcom has developed a technology neutral licensing approach called Spectrum Usage Rights[25];

- in the United States, some types of licences have conditions that allow considerable flexibility over spectrum use[26];

- in Europe, the Radio Spectrum Policy Group has developed the Wireless Access Policy for Electronic Communications Services concept in an attempt to move towards greater flexibility. It provides a framework for the provision of electronic communications services within a given set of bands, where the services may be offered on a technology and service neutral basis. In fact, policy in the European Union embraces the principles of technology neutrality and service neutrality[27].

The key elements of technology neutral spectrum licences are as follows:

- the licensee can use any technology to provide any service in any frequency band, and the use of the radio frequency spectrum can be changed at any time;

- the licensee must observe emission limits; and

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[24] Twenty-three Commercial LTE 1800 network launched in 18 countries namely Angola, Australia, Azerbaijan, Czech Republic, Croatia, Denmark, Finland, Germany, Hong Kong (China), Latvia, Lithuania, Namibia, Poland, Saudi Arabia, Singapore, South Korea, and the United Arab Emirates. Some 98 LTE user devices across all form factors have been announced. *Status of the LTE ecosystem report*, 3 July 2012. Available at www.gsacom.com

[25] The new 4G licences for 250 MHz of new bandwidth to be auctioned by Ofcom will be technology neutral.

[26] For example, the Personal communications Services licences whereby the licensee is free for the most part to provide any service - fixed, mobile, private, common carrier, etc. and is free to use any technology to do so.

[27] "Technological neutrality" means applying no constraints or prescriptions on choices of technology or equipment, within the bounds of compatibility and interference avoidance. "Service neutrality" means the spectrum holder can choose what service to offer using its spectrum rights.

- the licensee must manage interference (both in-band interference[28] and out-of-band interference[29]) between radiocommunications devices and services operating under other licences in the radio frequency spectrum bands.

4.6   Facilitating infrastructure sharing

In order to ensure the most efficient network deployment, affordable services and to reduce unsightly masts and antenna, it is important to ensure that the infrastructure policy is targeted at minimising inefficiencies while encouraging new investment.

Infrastructure sharing reduces the cost base and the need to duplicate infrastructure. It is therefore an important factor in facilitating the improved affordability of broadband services. Sharing is particularly important for smaller countries, both in terms of population and geography. Replication of broadband infrastructure can be costly, inefficient and unsustainable.

There are a number of factors that contribute to the need for countries to formulate an infrastructure-sharing framework *inter alia*:

- There are obvious capital expenditure constraints.
- There is greater susceptibility to natural disasters such as tropical storms and tsunamis, meaning infrastructure must be strategically positioned and be of high quality. This is less likely in cases of duplication.
- The unappealing aesthetic value of duplicated infrastructure like towers.
- An unnecessary duplication of towers and other passive infrastructure could have harmful effects on the environment.

4.7   Promoting wireless sector competition by instituting spectrum caps and mandated mobile virtual network operator (MVNO) models

4.7.1   Imposing spectrum caps

Consideration should be given to imposing spectrum caps and rules to avoid spectrum hoarding by one or two major mobile operators taking into consideration the total frequency owned by the mobile operators for LTE and broadband. In addition, imposition of pro-competitive safeguards including spectrum caps will address the significant market power that some operators may have in relation to existing services which will otherwise be carried forward into new wireless technologies. Such rules could apply to future spectrum bands.

Such spectrum caps are a mechanism used by regulators in a number of jurisdictions to improve market competition, secure benefits for users and avoid hoarding of spectrum. In fact, a large number of country markets are imposing, or considering imposing, caps for wireless broadband (including digital dividend spectrum) even where such caps were abolished or not favoured over the past few years. Such markets include Asian as well as Australian, European and North American countries. See Appendix C for a table detailing spectrum caps in selected markets.

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[28] In-band interference can be caused over large distance by co-channel (same frequency) emissions from transmitters operated under area-adjacent apparatus or radio frequency spectrum licences.

[29] Out-of-band interference occurs when transmitters and receivers operate close together in terms of the two main variables that determine their degree of isolation from each other: distance and/or frequency separation.

For example, operators with a disproportionate share of 900/1800 MHz spectrum should be precluded from securing more than 20 per cent of future 2.3 and 2.6 GHz spectrum auctions unless they are willing to hand back and/or trade existing spectrum blocks. Likewise, a single operator should not be entitled to hold more than one-third of the major cellular spectrum band allocations (i.e. in the key IMT bands – namely 700, 800, 900, 1800, 2100, 2300 and 2600 MHz spectrum bands).

4.7.2 Mandating MVNOs

While the concept of mobile virtual network operator (MVNO) has been prevalent in other countries since 1990s, the MVNO model has gained recent popularity, including in relation to 3G and LTE services. The MVNO model remains attractive for new players with potential entrants cutting across industries with majority non-telco based operators such as media companies, retailers and financial institutions[30].

Where mandated MVNO access is required by regulation in foreign markets, MVNOs have emerged as strong and vibrant competitors in markets for mobile communications services. There are good international precedents for such an approach. Examples of these foreign precedents – which include emerging and Asian markets - are detailed in Appendix D.

While it is true that many regulatory jurisdictions have previously adopted a 'light-touch' approach, favouring commercially negotiated agreements between wireless operators and MVNOs, a growing number of regulatory jurisdictions have mandated that wireless operators provide mandated access for MVNOs, whether through one-time or on-going regulation. This is especially in the case of LTE and 4G services which would require the right to provide MVNO services – both voice and data over one of the existing 2G/3G networks in order to offer a compelling product to consumers.

In summary, there are a number of key objectives - including policy, industry and technical developments in favour of promoting and regulating MVNOs in some countries in the Asia Pacific region looking to develop a wireless broadband masterplan. These include:

    i. promote greater wireless broadband competition including service competition;

    ii. promote greater cellular mobile (voice) competition including from potential 4G players;

    iii. acknowledge that radio frequency spectrum is a bottleneck and an entry barrier to potential new competitors; and

    iv. facilitate the future possible entry of a range of data only MVNO providers in the market including for machine to machine (M2M) communication.

Regulating MVNOs is likely to lead to increased offering of innovative service bundles to different segments of the population and to facilitate downstream innovations by mobile network providers in response to an MVNO market entry. This is in the interest of end users.

4.8 Other key policy and regulatory issues

Table 3 details a number of key policy and regulatory issues that have arisen during the course of the development of these Guidelines which ought to be implemented in order to facilitate wireless broadband services.

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[30] There is no uniform definition on what constitutes MVNO. According to ITU, the term Mobile Virtual Network Operator ("MVNO") is defined as "an operator that offers mobile services but that does not own its own radio frequency". MVNOs are basically resellers who do not own any telecommunications infrastructure or spectrum, purchase airtime at wholesale rates from mobile network operators and resells wireless subscriptions (and other value added services) under its own brand to the subscribers. MVNOs today have however gone beyond a simple reseller to being a full or "heavy" MVNO capable of providing a compelling mix of service to end users.

Table 3: Other key policy and regulatory issues

No.	Issues	Comments
1.	Utilisation of key spectrum below 1 GHz	Given the dominant position of mobile services and wireless broadband in the future, the need to best utilise key spectrum below 1 GHz (especially the 700 MHz band) is profound. The use of sub-1 GHz is important as it provides wide area coverage at a much lower cost. Besides, spectrum released in the process of transition from analogue to digital television transmission – called the `digital dividend', in the 700 MHz band (470 to 862 MHz) can be made available for wireless broadband.
2.	Determining spectrum price for 3G spectrum	For developing countries it may not be possible to have a real auction to determine the price that ought to be paid for spectrum. Proposals for the pricing of say 3G and/or 4G spectrum should be consistent with global and regional benchmarks. Some countries will need to use a benchmarking study to determine the prices for 3G spectrum. This is further discussed in Appendix E.
3.	Mobile number portability	While mobile number portability (MNP) may be desirable it is not always necessary and may add considerably to costs and network complexity when quality of service may already be an issue.
4.	Using satellites in rural, remote and uneconomic areas	Using satellites in rural, remote and uneconomic areas as part of a national broadband solution is both good public policy and makes commercial sense given this can provide cost-effective solutions that are robust and are ready to use requiring very little time for installation. In addition, such service could be utilised to provide or extend cellular network connectivity in areas without fibre or microwave facilities or direct connectivity when mini BTS are not economic.
5.	Role of regulator as facilitator	The role of the regulator as a facilitator is crucial in order to create an enabling environment, regulatory certainty and a gradual reliance on market mechanisms to promote wireless broadband services. This includes: • developing predictable and transparent regulatory framework; • promoting competition; • encouraging investment in infrastructure; • engaging in consultation with industry; and • quarterly collection of statistics from operators to ensure latest ICT figures so as to inform government decision making.

5   Managing spectrum scarcity and ensuring harmonisation

Masterplan Preparation Insight 10: Making available spectrum for a reasonable price for wireless broadband services in frequency spectrum bands designated for mobile/wireless services is a prerequisite for a quality wireless broadband masterplan. The masterplan therefore needs to make spectrum available in harmonised bands which is able to be used to deploy wireless broadband.

5.1   Introduction

ITU has been a driving force for over two decades for the development of global broadband mobile telecommunication system. International Mobile Telecommunications (IMT), supported by fixed telecommunication networks (e.g. PSTN/Internet) provides access by means of one or more radio links to a wide range of telecommunication services.

IMT is the generic ITU name for 3G/4G technologies. Radio spectrum below 1 GHz is optimum for the needs of developing countries, due to the ability to serve larger rural areas from a single cell site compared to spectrum above 2 GHz. The 2007 World Radio Conference made valuable strides in identifying additional spectrum for IMT, both below 1 GHz and above 2 GHz. The concept of identifying spectrum for potential use by IMT, in the ITU Radio Regulations, gives global equipment manufacturers some guidance on the range of frequency bands in which IMT services are likely to be deployed, leading to economies of scale and minimizing product costs. The identification "for those administrations wishing to deploy IMT" allows use by other services to which the spectrum is allocated and does not convey any priority for IMT over those other radio-based services.

IMT-Advanced provides a global platform on which to build the next generations of mobile services – fast data access, unified messaging and broadband multimedia – in the form of exciting new interactive services and applications. New studies/techniques are leading to increased spectrum utilization and spectrum efficiency and allowing spectrum resources to be shared between users. Studies in ITU aim to provide `hybrid broadband networks' with terrestrial and satellite components for wide area coverage and seamless connectivity. The objectives for the efficient management of spectrum are detailed in Box 5.

5.2 Identification of IMT bands

With the conclusion of the WRC 12, a three-year period of debate has commenced that will shape the face of mobile broadband for decades to come. Agenda item 8.2 of WRC-12 gave administrations the opportunity to support placing an item on the agenda of WRC 15 to plan the spectrum needs of the IMT sector through 2020 and beyond. Given the importance of broadband for socio-economic development, adoption of a new agenda item for international mobile telecommunications (IMT) has been supported by the world radio community at large.

There has been tremendous growth in the demand for mobile broadband applications since WRC 07 with multimedia capabilities. International Mobile Telecommunications (IMT) systems are the primary source of delivering wide area mobile broadband applications. In many developing markets the main delivery mechanism for broadband access is expected to be through mobile devices.

While IMT and other mobile broadband systems contribute to global economic and social development by providing a wide range of multimedia applications, such as mobile telemedicine, teleworking, distance learning and other applications, these systems could help reduce the digital divide between urban and rural areas, including underserved communities. Harmonized worldwide bands and harmonized frequency arrangements for IMT and other mobile broadband systems are highly desirable in order to achieve global roaming and the benefits of economies of scale.

There is a fairly long lead-time between the identification of frequency bands by world radiocommunication conferences and the deployment of systems in those bands, and timely availability of spectrum is therefore important to support the development of IMT and other terrestrial mobile broadband applications.

There is a need to continually take advantage of technological developments of spectrum and to facilitate spectrum access in order to increase its efficient use. At the same time adequate and timely availability of spectrum and supporting regulatory provisions are a pre-requisite for supporting future growth of IMT and other mobile broadband systems.

Proximity to bands already identified for IMT is expected to lead to reduced complexity and time in equipment design.

The need for cost-effective implementation of IMT, particularly in many developing countries and those with large areas of low population density, is of particular advantage. The use of lower frequency bands with large signal coverage is indeed the right choice for these purposes.

Box 5: Objectives for the efficient management of spectrum

Efficient management of the radio spectrum is a key component for the promotion of broadband access. In planning the implementation of IMT, the following objectives are desirable:

- to ensure that frequency arrangements for the implementation of IMT have longevity, yet allow for the evolution of technology;
- to facilitate the deployment of IMT, subject to market considerations and to facilitate the development and growth of IMT;
- to minimize the impact on other systems and services within, and adjacent to, the bands identified for IMT;
- to facilitate worldwide roaming of IMT terminals;
- to integrate efficiently the terrestrial and satellite components of IMT;
- to optimize the efficiency of spectrum utilization within the bands identified for IMT;
- to enable the possibility of competition;
- to facilitate the deployment and use of IMT, including fixed and other special applications in developing countries and in sparsely populated areas;
- to accommodate various types of traffic and traffic mixes;
- to facilitate the continuing worldwide development of equipment standards;
- to facilitate access to services globally within the framework of IMT;
- to minimize terminal costs, size and power consumption, where appropriate and consistent with other requirements;
- to facilitate the evolution of pre-IMT-2000 systems to any of the IMT terrestrial radio interfaces and to facilitate the on-going evolution of the IMT systems themselves;
- to afford flexibility to administrations, as the identification of several bands for IMT allows administrations to choose the best band or parts of bands for their circumstances;
- to facilitate determination, at a national level, of how much spectrum to make available for IMT from within the identified bands;
- to facilitate determination of the timing of availability and use of the bands identified for IMT, in order to meet particular user demand and other national considerations;
- to facilitate development of transition plans tailored to the evolution of existing systems;
- to have the ability for the identified bands, based on national utilization plans, to be used by all services having allocations in those bands;
- to enforce licensing conditions and adherence to licensed technical parameters; and
- to effect cross border coordination to eliminate / mitigate cross border interference situations.

Masterplan Preparation Insight 11: Decisions of the World Radio Conference-2012 (WRC-12) towards making available spectrum to fulfil the needs of the IMT sector through 2020 and beyond. Agenda for the WRC-15 and relevant studies in the interleaving period should be noted.

The advantages of the frequency bands below 1 GHz for wide coverage and those above 1 GHz for higher data rates with respect to use of IMT systems are noted in Resolutions 224 (Rev. WRC 12) and 223 (Rev. WRC 12), respectively. Refer to 'Provisional Final Acts of the WRC-12'[31].

Globally, there are currently some 1.6 billion IMT connections according to Wireless Intelligence Q4 2011[32]. IMT includes all significant mobile broadband technologies, so the success of IMT is, in effect, the same as the success of mobile broadband. For IMT and mobile broadband to reach their full potential, suitable and sufficient harmonized spectrum will have to be identified to cater for the projected growth.

The spectrum for IMT identified by the WRC 07 did not entirely match the demand predicted in ITU studies. The spectrum that was identified for the UHF band at 700 or 800 MHz is being exploited around the world, and many more assignments are expected in 2012.

Almost all terrestrial spectrum identified at previous radio conferences is either heavily used (3G core bands), or is currently being awarded (2.6 GHz extension bands) in most markets. This has allowed economies of scale to develop for IMT technologies, which has spurred incredible global growth of mobile broadband. There are nearly 670 million HSPA (High-Speed Packet Access) subscribers today.

Studies show that the transmission of data over mobile networks has grown rapidly during the past few years, with seven times greater traffic in 2010 than was predicted by ITU in 2005.

There are many bands in the Radio Regulations that have primary mobile allocations but are not available for mobile broadband applications because there is no suitable equipment ecosystem. Such ecosystems create economies of scale and lead to lower-cost devices. In order to create these ecosystems, an identification of spectrum for IMT is required.
An allocation to the mobile service and identification for IMT at WRC 15 would imply that such spectrum might not become available until 2025 (or later in some markets). There are very long lead times between allocation, identification and the final use of the spectrum by consumers. For example, the core spectrum for 3G/IMT (UMTS in Europe) was identified by the ITU World Administrative Radio Conference in 1992. It was finally awarded around 2000 and was not fully available until around 2004. This makes it important to ensure that the planning process for identifying spectrum takes place in good time to allow for the long time horizons. The benefits of international harmonization are great for mass-market services such as mobile.

5.3   Key decisions on IMT issues in WRC-12

Allocation of the band 694-790 MHz (also called the digital dividend 2 band) to mobile service in Europe, Middle East and Africa (ITU Region 1) from 2015 subject to further studies and confirmation by WRC-15

To identify new spectrum for mobile broadband, studies were approved to be undertaken during the period in 2012-2015 by a `Joint Task Group' (JTG) to find new spectrum for mobile broadband and mobile telephony. This will allow WRC-15 to allocate additional bands for mobile broadband and mobile telephony.

A decision was taken to cater to the needs for broadband public safety. The ITU-R Study Group 5 in general and Working Party - 5A (WP-5A) in particular, conducted studies towards broadband public safety (PPDR-Public Protection and Disaster Relief). The WRC-12 approved further studies during the period 2012-2015 in order to allow WRC-15 to review and decide on the needs for broadband public safely. PPDR refers to radiocommunications used by responsible agencies and organisations dealing with maintenance of law and order, protection of life and property and emergency situations.

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[31]   www.itu.int/md/R12-WRC12-R-0001/en

[32]   www.wirelessintelligence.com/analysis/2012/01/global-cellular-market-trends-and-insight-q4-2011

The Conference Preparatory Meeting (CPM) for WRC-15 Geneva, 20-21 February 2012 decided to establish the Joint Task Group JTG 4-5-6-7 as the responsible group for the WRC-15 Agenda Items 1.1 and 1.2[33]:

- Agenda item 1.1: to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution COM6/8 (WRC 12).

- Agenda item 1.2: to examine the results of ITU R studies, in accordance with Resolution COM5/10 (WRC 12), on the use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile service in Region 1 and take the appropriate measures.

5.4   Frequency arrangements for implementation of IMT

> **Masterplan Preparation Insight 12:** Selection of transmitting and receiving frequency arrangements for the terrestrial component of IMT systems in accordance with Recommendation ITU-R M.1036-4 dealing with Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR), was approved in March 2012 and should be taken account of in any wireless broadband masterplan.

Recommendation ITU-R M.1036-4 deals with frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR). It provides guidance on the selection of transmitting and receiving frequency arrangements for the terrestrial component of IMT systems.

The recommendations aim at achieving the most effective and efficient use of the spectrum while minimizing the impact on other systems or services in these bands, as well as facilitating the growth of IMT systems.

General considerations regarding technological aspects:

- IMT (IMT-2000 and IMT-Advanced) radio interfaces currently include two modes of operation – frequency division duplex (FDD) and time division duplex (TDD).

- There are benefits in the use of both FDD and TDD modes in the same band. However, this usage requires careful consideration to minimize the interference between the systems. If flexible FDD/TDD boundaries are selected, there may be a need for additional filters in both transmitters and receivers, guard bands that may impact spectrum utilization, and the use of various mitigation techniques for specific situations.

- Selectable/variable duplex technology is considered to be one technique that can assist in the use of multiple frequency bands to facilitate global and convergent solutions. Such a technology could bring further flexibility to allow IMT terminals to support multiple frequency arrangements.

- When frequency arrangements cannot be harmonized globally, a common base and/or mobile transmit band would facilitate the development of terminal equipment for global roaming. A common base transmit band, in particular, provides the possibility to broadcast to roaming users all information necessary to establish a call.

- Guard bands for IMT systems should be minimized to avoid wasting spectrum.

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[33] www.itu.int/md/R12-CPM15.01-120220-TD-0005/en

- When developing frequency arrangements, current and future advances in IMT (e.g. multimode/multiband terminals, enhanced filter technology, adaptive antennas, advanced signal processing techniques, techniques associated with cognitive radio systems, variable duplex technology and wireless connectivity peripherals) may facilitate more efficient use and increase overall utilization of radio spectrum.

- In terms of frequency availability it is recommended that administrations make available the necessary frequencies for IMT system development in a timely manner.

The frequency bands identified for IMT services (that accommodate all the technologies) are shared bands with footnotes:

Band (MHz)	Radio Regulation Footnotes identifying the band for IMT
450-470	5.286AA
694-790/698-806*/790-862*, 806 - 960	ADD 5.3XX, MOD 5.313A, MOD 5.317A
1 710–1 885, 1 885-2 025	5.384A, 5.388
2 110-2 200	5.388
2 300-2 400	5.384A
2 500-2 690	5.384A
3 400-3 600	MOD 5.430A, 5.432A, 5.432B, 5.433A

World Radio Conference - 1992

World Administrative Radio Conference –2000

World Administrative Radio Conference – 2007

World Administrative Radio Conference – 2012 (Allocation shall enter into force immediately after WRC 2015)

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* 790-862 MHz (Allocation for Region 1 and 3)

698-790 MHz (Allocation for Region 2 and 9 countries in Region 3: Bangladesh, China, Rep. of Korea, India, Japan, New Zealand, Papua New Guinea, Philippines and Singapore)

By taking these Radio Regulations footnotes and relevant resolutions into account, administrations have the flexibility use these bands according to each administration's evolution/migration plan.

A minimized number of globally harmonized frequency arrangements in the bands identified for IMT 2000 by one or more conferences will:

- facilitate worldwide compatibility; and
- facilitate international roaming.

Annex 1 (Sections 1 to 6) of Recommendation ITU-R M.1036-4 describes the frequency arrangements for implementation of IMT in the bands identified for this service in the Radio Regulations (RR).

The order of the frequency arrangements does not imply any priority. Administrations may implement any of the recommended frequency arrangements to suit their national conditions. Administrations may implement all or part of each frequency arrangement.

It is noted that administrations may implement other frequency arrangements (for example, arrangements which include different duplex schemes, different FDD/TDD boundaries, etc.) to fulfil their requirements. These administrations should consider neighbouring deployments and should aim at achieving economies of scale, facilitating roaming, and minimising interference.

Administrations should take into account the fact that some of the different frequency arrangements in the same band have an overlap of base station transmitter and mobile station transmitter bands. Interference problems may result if different frequency arrangements with such overlaps are implemented by neighbouring administrations.

Annex 1 describes ten frequency arrangements for the implementation of IMT in the band 450-470 MHz. The number of frequency arrangements help to accommodate incumbent operations, while maintaining a common uplink/downlink structure (uplink in the lower 10 MHz, downlink in the upper 10 MHz) for FDD arrangements.

The recommended frequency arrangements for implementation of IMT in the band 698 960 MHz are summarized in Box 6 and Figure 8.

Box 6: Paired frequency arrangements in the band 698-960 MHz					
Frequency arrangements	**Paired arrangements**				**Un- paired arrangements (e.g. for TDD) (MHz)**
	Mobile station transmitter (MHz)	**Centre gap (MHz)**	**Base station transmitter (MHz)**	**Duplex separation (MHz)**	
A1	824-849	20	869-894	45	None
A2	880-915	10	925-960	45	None
A3	832-862	11	791-821	41	None
A4	698-716	12	728-746	30	716-728
	776-793	13	746-763	30	
A5	703-748	10	758-803	55	None
A6	None	None	None		698-806

Due to different usages in 698-960 MHz between regions, no common solution is possible.

In the arrangement A3, reversed duplex direction (mobile transmit in upper band and base transmit in lower band) provides better conditions for coexistence with the lower adjacent broadcasting service.

In arrangement A4, administrations can use the band solely for FDD or TDD, or some combination of the two. Administrations can use any FDD duplex spacing or FDD duplex direction. However, when administrations choose to deploy mixed FDD/TDD channels with a fixed duplex separation for FDD, the duplex separation and duplex direction as shown in A4 are preferred.

In A5, the 2 x 45 MHz FDD arrangement uses sub blocks with dual duplexer solution and conventional duplex arrangement. Internal guard bands of 5 MHz and 3 MHz are provided at the lower and upper edge of the band for better co-existence with adjacent radio communication services.

In A6, taking into account the external 4 MHz guard band (694-698 MHz), a minimum internal guard-band of 5 MHz at the lower edge (698 MHz) and 3 MHz at the upper edge (806 MHz) needs to be considered.

Figure 8: Frequency arrangements for the 698 to 960 MHz band
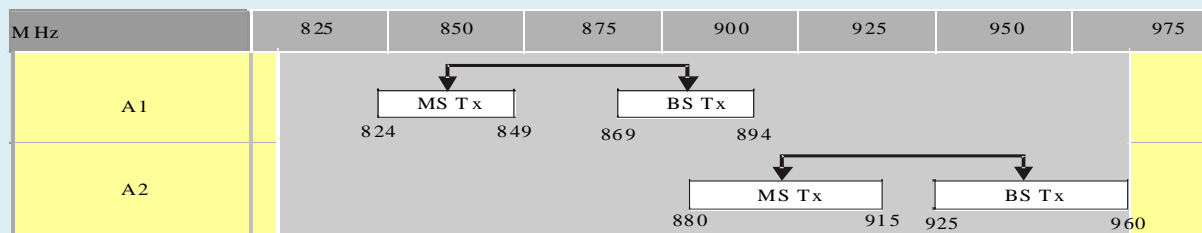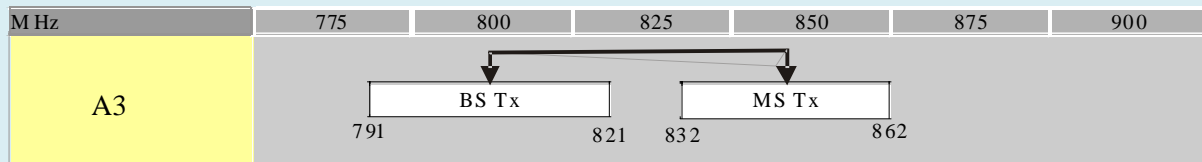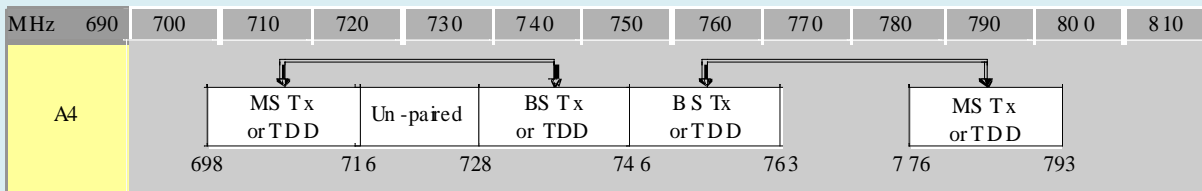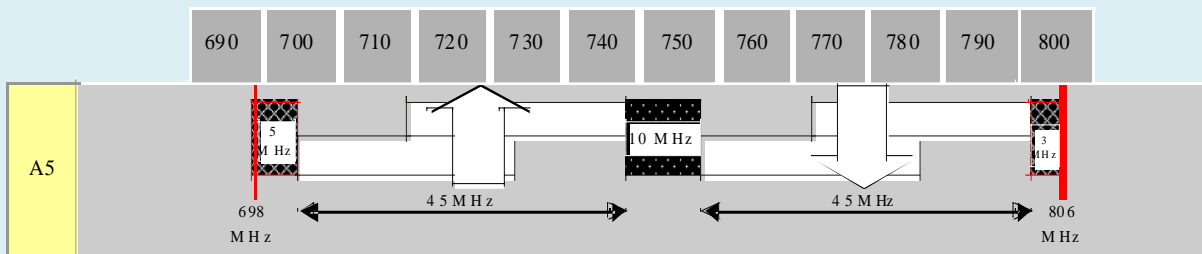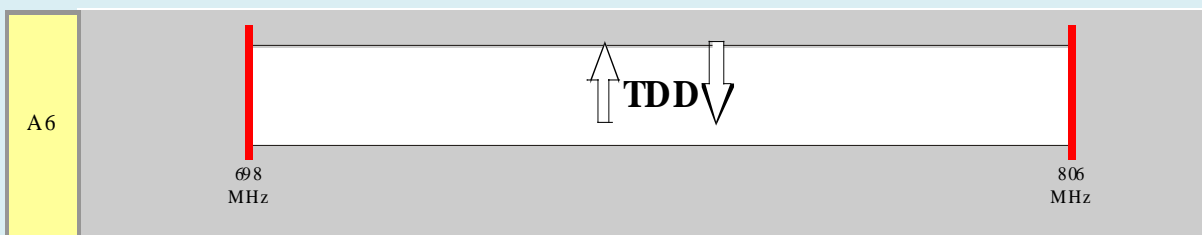
Source: ITU

Frequency arrangements in the band 1710-2200 MHz are depicted in the Figure 9.

Figure 9: Frequency arrangements in the 1710-2200 MHz band
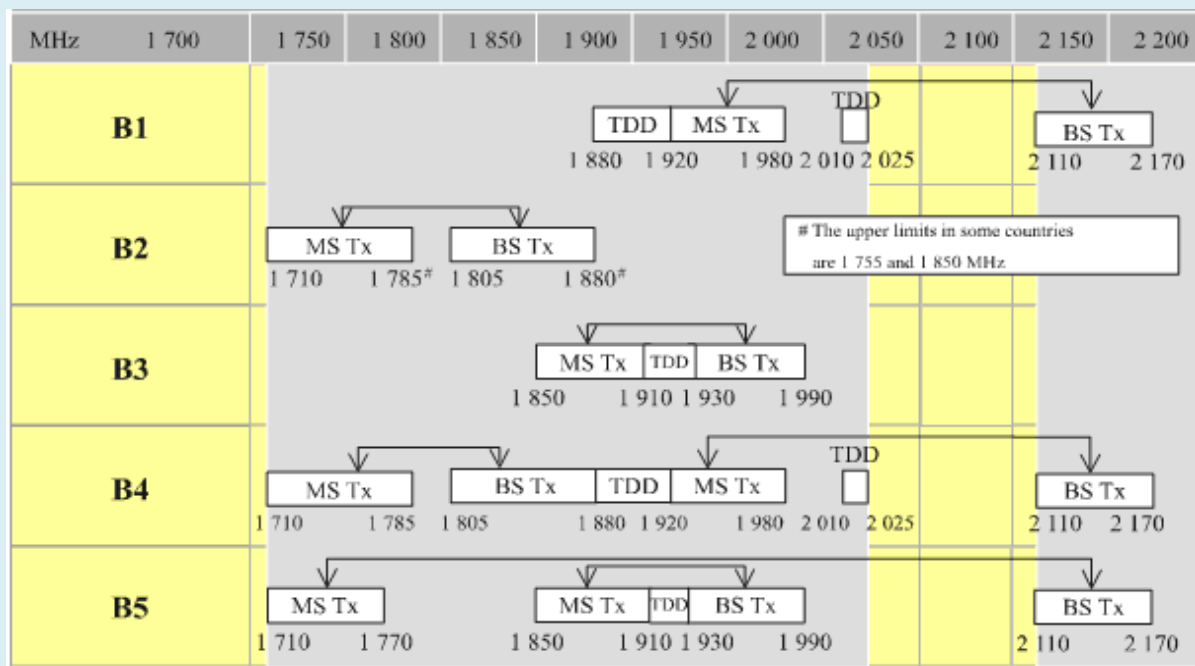
Source: ITU

In bands 1710-2025 MHz and 2110-2200 MHz three basic frequency arrangements (B1, B2 and B3) are already in use by public mobile cellular systems, including IMT. Based on these three arrangements, different combinations of arrangements are recommended as described in B4 and B5.

Frequency arrangements in the band 2300-2400 MHz and 2500-2690 MHz are summarised in Figure 10.

Figure 10: Frequency arrangements in the 2300-2400 and 2500-2690 MHz bands
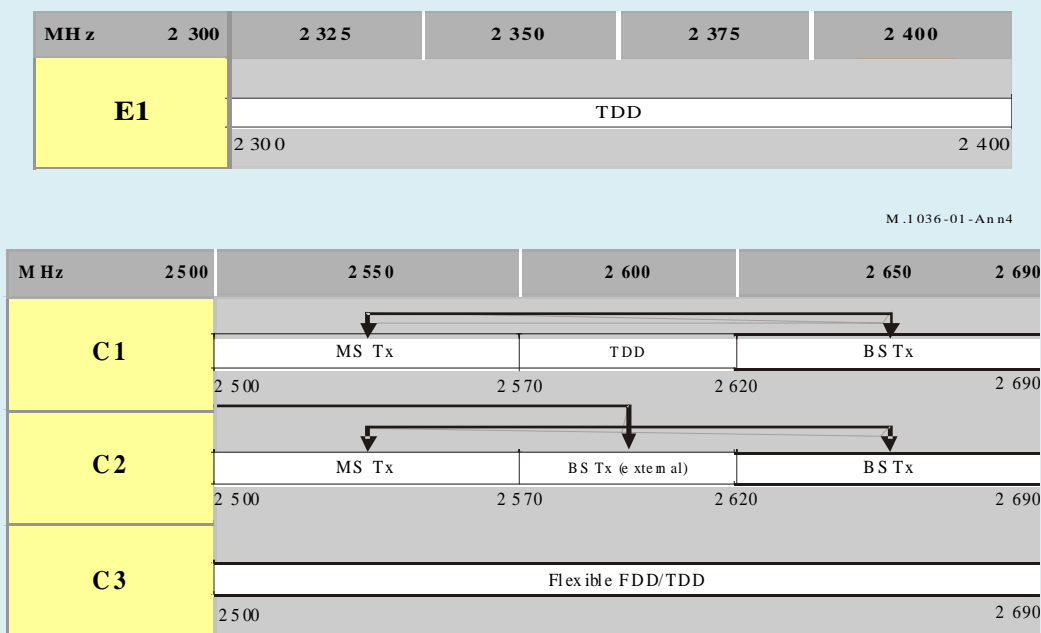
Source: ITU

Figure 11 describes frequency arrangements for the band 3400 to 3600 MHz.

Figure 11: Frequency arrangements in the 3400 to 3600 MHz bands					
Frequency arrangements	**Paired arrangements**				**Un-paired arrangements (e.g. for TDD) (MHz)**
	Mobile station transmitter (MHz)	**Centre gap (MHz)**	**Base station transmitter (MHz)**	**Duplex separation (MHz)**	
F1					3400 - 3600
F2	3410 - 3490	20 MHz	3510-3590	100 MHz	None

Source: ITU
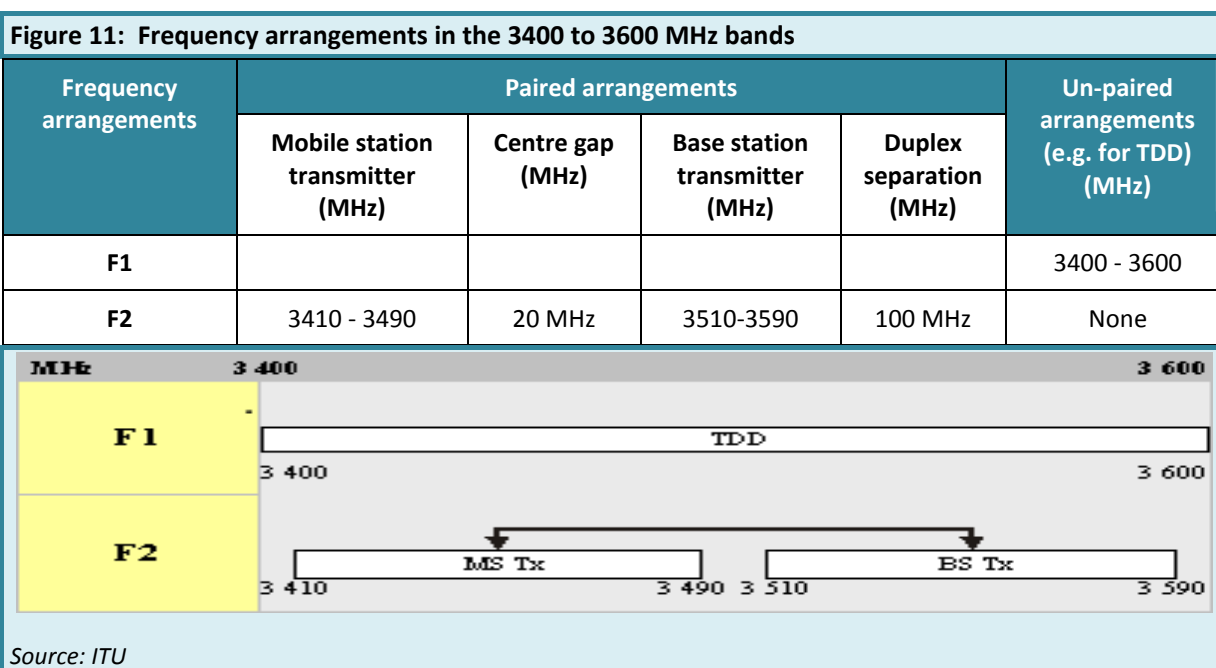
Below is a summary of guidelines in favour of a more orderly approach for spectrum arrangements:

- To take advantage of mass-market deployments, the internationally harmonized frequency arrangements offer significant clear advantages to end-users, wireless operators and administrations.

- If FDD and TDD systems are used in a band, a common FDD-TDD frequency boundary should be used internationally to reduce the potential of interference, and reduce the complexity, size and cost of the equipment, otherwise national band plans increase market fragmentation and lead to limited consumer choice.

- Interference between TDD and FDD systems should be analysed with the particular characteristics of the intended systems. A frequency separation (typically 5 MHz) between FDD and TDD systems operating in the same geographical area is always required for a normal operating radio frequency power. Furthermore, additional filters of the order 50 dB are necessary for both receiver and transmitter when applying a frequency separation of 5 MHz between FDD and TDD operations. The same applies for the space between unsynchronized TDD operations. Without filters, the frequency separation needs to be more than 10 MHz, and so it will not be spectrum efficient to have a large number of sub-bands. Therefore, the number of cross-over points between FDD and TDD or unsynchronized TDD operations should be kept to a minimum.

- When there are deployments following different band plans for FDD and TDD operation, the interference situation should be analysed. Interference will result if base stations are operating TDD and FDD modes according to different band plans at geographical borders under a multitude of FDD/TDD arrangement situations. The required separation distance may be in the order of 75 km. It is thus beneficial to harmonize spectrum arrangements within a geographical region.

- A common band plan should be adopted internationally. Considering mass-market terminal devices under a multitude of arrangements would lead to situations where users are coming close to each other. Where interference cannot be managed, users would experience significant capacity loss, which would be unacceptable for quality and real time services.

- Time coordination between adjacent operators may be a practical alternative to a geographical or spectral separation when TDD is used by both operators.

5.5   Spectrum needs and frequency arrangements based on technology selection

More than 90 per cent[34] of the world's population is under the coverage of mobile networks, which compared with the global Internet penetration of about 30 per cent[35] represents a huge potential for mobile broadband to become a major access enabler. For the majority of people in developing countries, the first and only access to the Internet is performed via an IMT network. This type of internet access is spreading very fast.

Figure 12 indicates the fixed and mobile broadband penetrations in percentages for different regions of the world.

Figure 12: Fixed and mobile broadband penetration 2010

Source: ITU World Telecommunications/ICT Database
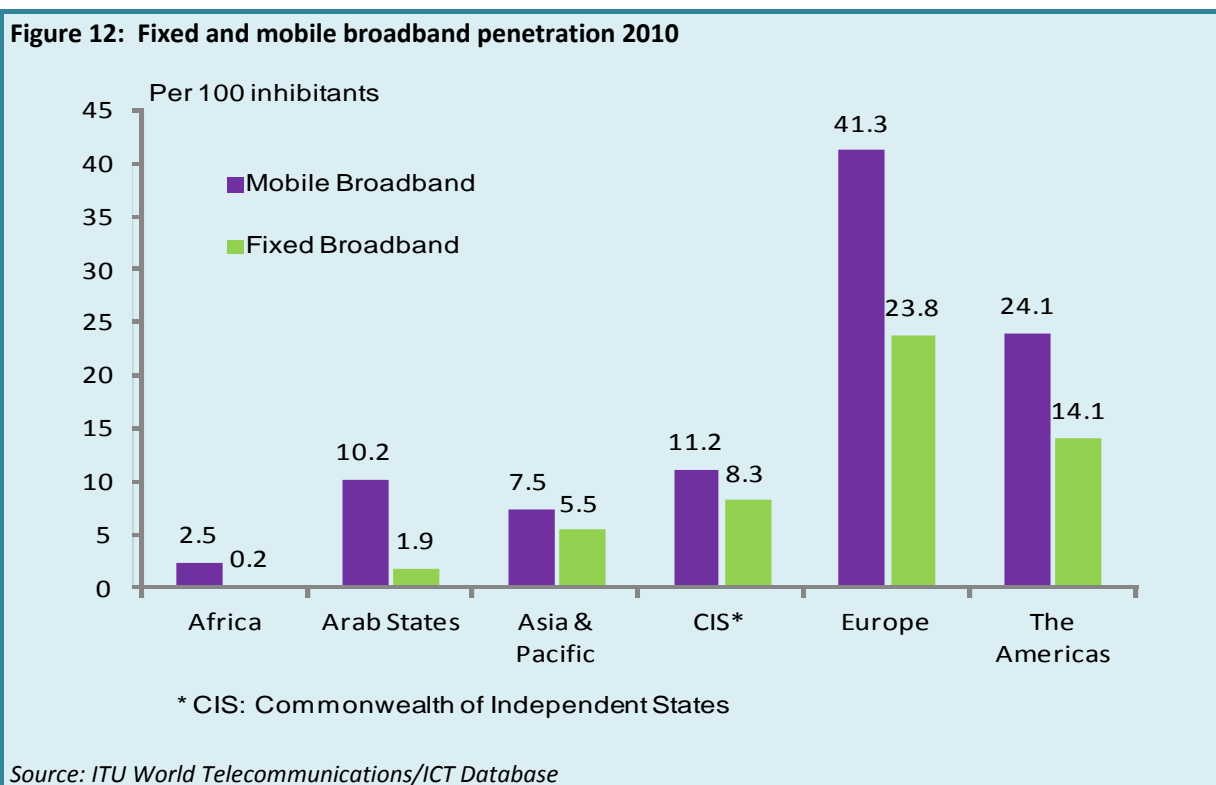
Trends that have contributed towards an increased demand for mobile broadband are:

- new type of devices, such as smart phones, dongles, tablets;
- mobile Internet usage is increasing;
- huge increase of mobile applications;
- video traffic is growing dramatically;
- media rich social networks go mobile;
- machine-to-machine traffic is growing and expanding to new applications;
- more capable network – user experience improvement;
- cost reduction and price decrease;
- Several policy initiatives to promote mobile broadband;
- potential area to increase data traffic; and
- broader user-age demographics and its impact on traffic growth.

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[34] https://communicationsdirectnews.com/do.php/100/41984?7649: "UN Report Finds Global Mobile Coverage at More Than 90%" (October 20, 2010).

[35] www.internetworldstats.com/stats.htm

According to the ITU Statshot Issue 7, August 2011[36], in 2010, almost 100 economies had mobile cellular penetration over 100 per cent – and 17 economies[37] had penetration rates above 150 per cent as depicted in Figure 13.

Figure 13: Mobile penetration for various economies
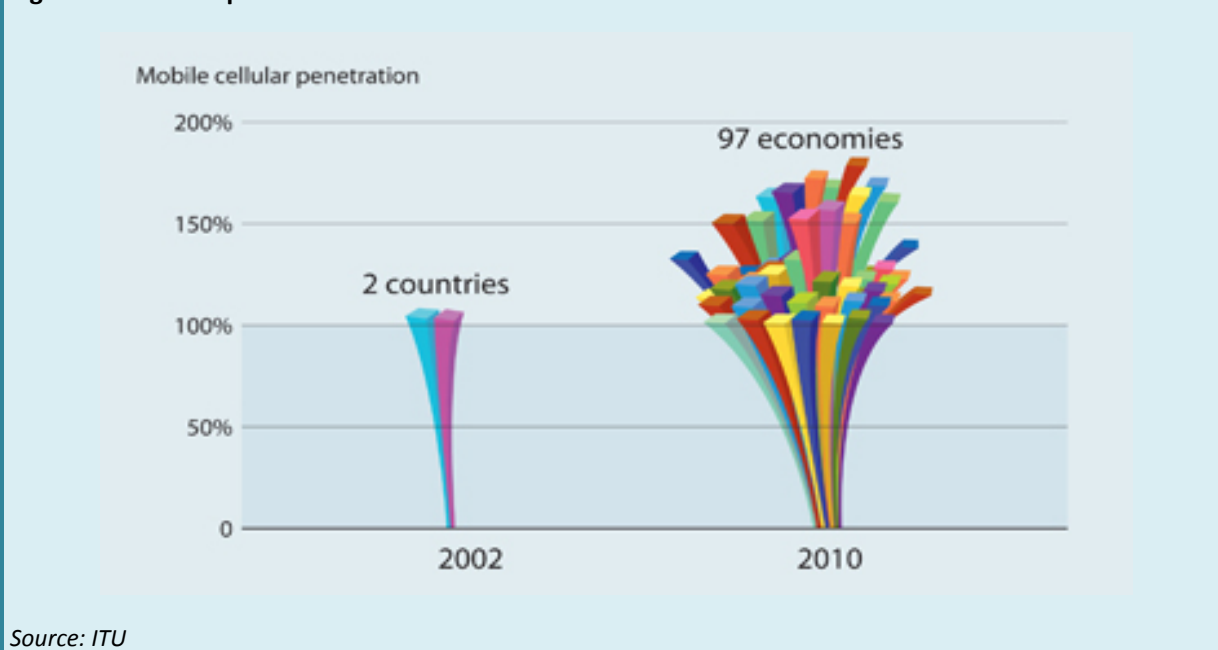
Source: ITU

The mobile broadband manufacturing industry is continuously evolving towards more efficient radiocommunication technologies, coupled with an all-IP open Internet network architecture. Through innovations like beam forming antenna systems, interference mitigation, multiple and aggregated carriers, power control, repeaters and scheduling schemes, etc., efficiency of spectrum usage has been achieved.

The number of IMT users is growing strongly in the Asia-Pacific region. In August 2011, 1.535 billion[38] people among the global population of 6.9 billion people were connected via IMT mobile broadband networks. As of mid-2011 there were about 6 billion[39] mobile subscriptions globally, and at the end of 2010 there were almost 4 billion mobile cellular subscriptions[40] in the developing world with active SIM cards.

The latest IMT technologies are capable of providing theoretical connection speeds ranging from 3.6 Mbit/s to 100 Mbit/s. The total IMT population coverage has increased over recent years but is heterogeneous, depending on the country. Indeed, the first areas with mobile broadband coverage were cities where the density of population is highest. Other areas are now being covered and refarming enables operators to use the bands below the 1 GHz frequency, which provides properties for larger cell radius than the bands around 2 GHz.

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[36]   www.itu.int/net/pressoffice/stats/2011/03/index.aspx

[37]   The 17 economies are: Anguilla, Finland, Maldives, Kuwait, St Kitts and Nevis; Oman, Russia, Suriname, Libya, Viet Nam, Cayman Islands, Antigua and Barbuda, Panama, Montenegro, Saudi Arabia, Hong Kong (China) and Macao (China).

[38]   UMTS Forum 799 million and CDG 738 million = 1.535 billion on 2011-08-15.

[39]   GSA/Informa Telecoms & Media 5.214 billion (GSM, HSPA and LTE), CDG 738 million (cdma2000 and EV-DO) and WiMAX 20 million.

[40]   www.itu.int/net/pressoffice/stats/2011/03/index.aspx

As seen Figure 14, the relative Capex as well as the cell radius favour the use of 700 MHz as compared to higher frequency bands.

Figure 14: Capex and cell radius for 700 MHz
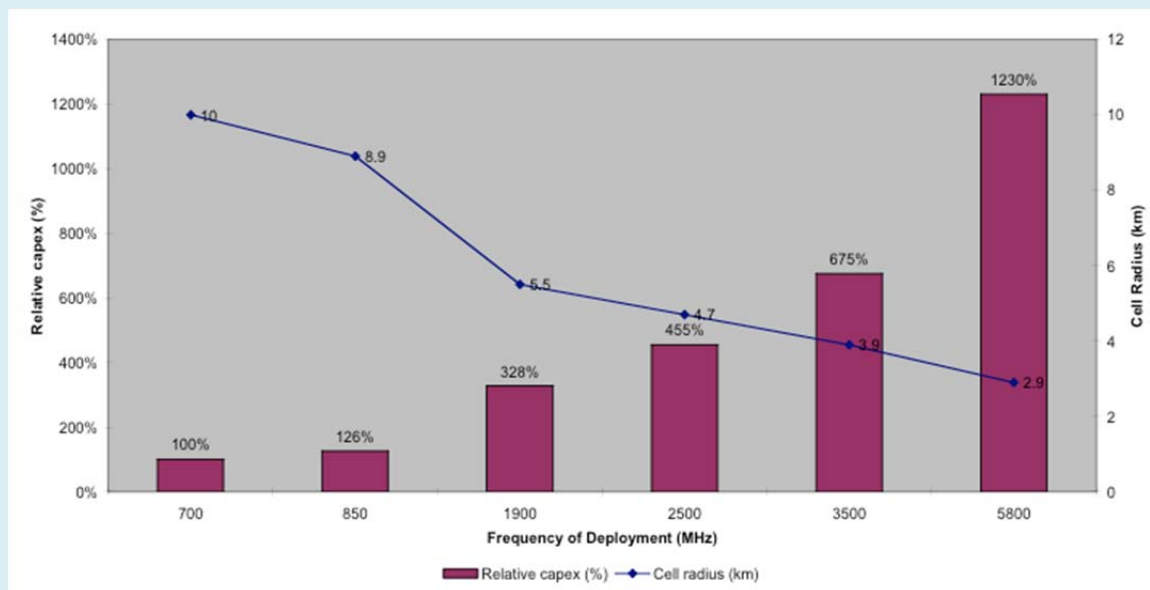
Source: ITU

While a number of frequency bands below and above 1 GHz have been identified in the Radio Regulations for IMT service (section 5.2), these can be used to cater to a number of wireless broadband technologies.

Technical and operational information for identifying Spectrum for the terrestrial component of future development of IMT-2000 and IMT-Advanced is contained in Report ITU-R M.2079. This report also includes details of 'band usage' and 'sharing studies' for each of the frequency bands identified for IMT.

Factors relevant to choosing potential spectrum for the IMT service include:

   i.   evaluation of suitable frequency ranges including the advantages/disadvantages and the results of sharing studies;

   ii.   estimation of the time-frame in which the spectrum will be needed in the most countries; and

   iii. recourse to the set of interdependent ITU-R Recommendations and reports.

While frequency bands above 1 GHz for IMT applications could be useful in large populated cities, the lower frequency bands with better building penetration and smaller foliage loss are more cost effective and have larger coverage.

700 MHz band is generally referred to as the bandwidth in between 698 to 806 MHz. This entire band was unanimously adopted by WRC-07 as the future IMT band and was recommended by ITU to its Member States to free up as soon as practicable.

WRC-07 developed WRC-12 agenda item 1.17 to consider the results of sharing studies between the mobile service and other services in the band 790-862 MHz in Regions 1 and 3, in accordance with Resolution 749 (WRC-07), to ensure the adequate protection of services to which the frequency band is allocated. The Resolution 749 as revised by WRC 12 and the footnote MOD 5.316A bring out the conclusions of the deliberations during the WRC-12 on agenda item 1.17.

With the availability of 790-862 MHz (Allocation for Region 1 and 3) Region 3 countries are well poised to exploit the gains of this band for IMT advanced service in general and LTE in particular.

IMT advanced technologies can now be implemented at lower bands, and 700 MHz is proving to be most effective for deployment in rural or high-cost regions. It is also economically viable – an LTE network at

700 MHz would be 70 per cent cheaper to deploy than an LTE network at 2.1 GHz (GSM Association). Two to three times fewer sites are required for initial coverage at 700 MHz as compared to 2.1 or 2.5 GHz bands (Figure 15).

Figure 15: Use of 700 MHz compared to higher frequency bands

	700 MHz Propagation	1800 MHz Propagation	2400 MHz Propagation
Total Network Cost per cell	$150,000	$600,000	$1,500,000
Network Cost per Customer	$65	$180	$1820
# Months to network cost breakeven	9 Months	36 Months	91 Months

700 MHz Coverage 1800 MHz Coverage 2400 MHz Coverage

Source: www.alohapartners.net

5.6　Estimates of overall spectrum needed for wireless services

5.6.1　ITU estimates of spectrum needed for wireless services

The methodology for calculation of spectrum requirements for the terrestrial component of IMT service can be seen from Recommendation ITU-R M.1390 and Recommendation ITU-R M.1768.

Administrations wishing to estimate spectrum requirements for the future development of the terrestrial component of IMT may use the methodology adopted by ITU in these recommendations. The methodology is a general one that can be used for differing markets, and for a range of cellular system architectures. Care should be exercised when choosing input parameters to reflect the requirements of particular countries or regions.

The methodology accommodates a complex mixture of services from market studies with service categories having different traffic volumes and QoS constraints. It also takes into account the time variations and regional variations in traffic and applies a technology neutral approach to deal with emerging as well as established systems.

Report ITU-R M.2078 allows for the estimation of spectrum bandwidth requirements for IMT service. This Report was developed in 2006 and needs revision since it primarily dealt with IMT-relevant future mobile communication RATG (Radio Access Techniques Groups) focusing on spectrum requirements for the preparation of WRC-07 Agenda item 1.4. This report also provided results of technical studies on estimated spectrum requirements for the future development of IMT-2000 and for IMT-Advanced as defined by ITU-R.

While using the market data in the year 2010 onwards from external organisations outside ITU, the estimated spectrum requirements were calculated with the spectrum calculation methodology defined in Recommendation ITU-R M.1768. In the spectrum calculation for the future development of IMT- 2000 and IMT-Advanced, new concepts were introduced, including a mix of services, multiple complementary systems, and RATG.

The estimated total spectrum bandwidth requirement for both the RATG1 and RATG2 for the year 2020 is calculated in this report to be 1,280 MHz (including spectrum already used, or planned to be used, for RATG1). Estimates of spectrum bandwidth requirements range from 1,280 MHz to 1,720 MHz (including spectrum already used, or planned to be used, for RATG1), which represented a lower and higher market setting as developed from the data in report ITU-R M.2072. It should be noted that the lower figure (1,280 MHz) is higher than the anticipated requirements for some countries which may have a need for less or no additional spectrum. In addition there are some countries where the requirement is larger than the higher value (1,720 MHz).

5.6.2   Updated foreign regulator estimates of spectrum needed for wireless services

Masterplan Preparation Insight 13: A wireless broadband masterplan – along with other sector policies should inform and create a shared set of goals for all market participants.

Other markets and regulators are also grappling with forecasting the quantum of spectrum needed for wireless services in the future given the significant uptick in demand. In three major studies in 2011, regulators in the United States, Australia and the United Kingdom carried out analysis to determine the amount of spectrum that is needed in their markets for wireless broadband services[41].

Such analysis challenges the ITU spectrum demand forecasts principally because the ITU-R report did not provide an easily applied methodology for particular countries to apply to their individual country circumstances. Furthermore, technical change in the past four years has been rapid and those advance likely further advancements in wireless technology in the period from now until 2020 need to be taken account of.

The first study is from the United States. In last year's FCC Staff Technical Paper entitled Mobile Broadband: The Benefits Of Additional Spectrum, October 2010[42] it was concluded that mobile broadband services are experiencing significant growth, driven by consumer demand for mobile data and that even with substantial investment, it is likely that mobile data demand will exhaust spectrum resources within the next five years. As existing US spectrum allocations are currently comparatively low, the paper goes on to state that a spectrum deficit approaching 300 MHz is likely by 2014, and that the benefit of releasing additional spectrum is likely to exceed USD 100 billion.

The current US focus seems to be on releasing 120 MHz of additional frequency from the UHF and VHF television bands for wireless broadband. To this end the FCC asked to look at more spectrally efficient ways of providing the distribution of TV broadcast services using wireless broadband. This resulted in a paper for Ericsson that digital TV broadcasting, which in the US utilises 300 MHz of spectrum, could be

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[41]   The German regulator the Bundesnetzagentur released (on 6 July 2011) papers assessing further spectrum needs as part of its review of the current allocation of existing 900 and 1800 MHz spectrum. See www.bundesnetzagentur.de/SharedDocs/Downloads/EN/BNetzA/PressSection/ PressReleases/2011/110706FrequencyUse.pdf?__blob=publicationFile.

[42]   This was preceded by a Wireless Association in the USA (CTIA) study which estimated in 2009, that the US needs at least 800 MHz of additional bandwidth for mobile broadband services within the next six years.

delivered over LTE networks using Multimedia Broadcast/Multicast Service (MBMS) technology in just 28 per cent of this spectrum[43].

The second study is from the United Kingdom. In February 2011, consultants Real Wireless prepared a Study entitled Report for Ofcom: 4G Capacity Gains[44] for the UK telecommunications regulator, Ofcom, on issues associated with the capabilities and potential of 4G technologies as well as topological improvements to wireless networks that will be necessary to expand supply in the medium term. A short summary of the study is attached as Appendix F.

Ofcom initiated the study as the exponential growth in mobile broadband penetration had prompted it to examine and which necessary rectify growing capacity concerns associated with the use of scarce spectrum.

The study makes a number of significant observations about the spectral efficiency of 4G technologies over 2G and 3G services. It queries previous studies on 4G network-capacity improvements over 3G which it considers which rely heavily on the accuracy of forecasting models. In contrast they emphasise the importance of network topology to improving capacity. They consider that this would take the form of more numerous cells, smaller cells and wireless offloading techniques. In overall terms, the consultants detail a strong case for LTE as the most spectrum efficient technology (Table 4).

Table 4: Real Wireless findings for spectrum efficiency for 3G and 4G network in ITU Urban macrocell test case[45]

	WCMA (Rel-99)	HSPA (R5)	HSPA (R6)	HSPA+ (R7)	LTE (R8)	LTE-A (R10)	WiMAX (Rel-1)	WiMAX (Rel1.5)	WiMAX (Rel-2)
Low end	0.19	0.28	0.41	0.41	1.12	2.09	0.83	1.17	2.03
Typical	0.19	0.45	0.68	0.68	1.32	2.60	1.18	1.41	2.41
High end	0.19	0.50	0.76	1.13	2.08	5.44	1.60	2.60	4.31

In the third study, in May 2011, the Australian Media and Communications Authority (ACMA) published two papers, *'Towards 2020 – Future spectrum requirements for mobile broadband'* and *'The 900 MHz band – Exploring Opportunities[46]'*, that outlined possible approaches to effectively meet growing demand for mobile broadband. See Appendix G for a summary of these papers. ACMA predicts an enormous 500-fold increase in data demand from 2007 to 2020 with nearly 1100 MHz of spectrum being estimated to be required to meet demand. In Australia, additional spectrum as detailed in Table 5 has been earmarked for mobile broadband services to address this spectrum demand.

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[43] See Ericsson, 2011 IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), Spectrum Requirements for TV Broadcast Services using Cellular Transmitters, Available at www.ericsson.com/res/thecompany/docs/journal_conference_papers/wireless_access/p22-huschke.pdf

[44] Version 1.5, 27 January 2011

[45] See page 11

[46] ACMA states that the 900 MHz band is identified as premium spectrum due to its ability to carry signals over long distances and penetrate walls. Presently, the band is being used for a variety of services including CMTS, digital CMTS (GSM), point-to-point and land mobile.

Table 5: Preferred wireless broadband and possible uses for candidate bands

Band	Possible Uses
850 MHz	• LTE / LTE Advanced
1.5 GHz	• W-CDMA – HSPA / HSPA+ • LTE / LTE Advanced • WiMAX TDD/FDD
Mobile Satellite	• Embargo in place. Prevents applications for apparatus licences for fixed and mobile services in 1980-2010 MHz and 2170-2200 MHz bands.
1675-1710 MHz	• Will monitor FCC's progress. Indication that Met Sat services will be significantly affected by introduction of mobile broadband in this band.
2010-2025 MHz	• LTE / LTE Advanced • W-CDMA – HSPA / HSPA+
3.3 GHz	• FDD • TDD
3.4 GHz	• WiMAX FDD/TDD • LTE / LTE Advanced
3.8 GHz	• WiMAX FDD/TDD • WiFi (TDD) • LTE / LTE Advanced
4.2 GHz +	• Considering bands between 4.2 – 6 GHz • This spectrum is suited for in-home services and Femtocell offloading.

5.6.3 Summary of overall spectrum requirements

Suggested overall spectrum allocation targets

Summarising these various studies there is little doubt that most markets – with the exception of smaller markets – there is a need for greater allocations of spectrum to wireless/cellular services in order to support the efficient provisioning of services (at affordable prices) and to support the country's economic growth. While the optimal timing to secure additional spectrum needs to be ascertained the extended time period in which to facilitate new spectrum releases will always make this difficult to do perfectly.

As to the overall target level of spectrum that any Asia Pacific country should aim to have allocated, it is recommended that the minimum spectrum allocation for cellular mobile services should be at least 760 MHz in 2020 and preferably 840 MHz (Figure 16). Many countries in the region are significantly below this target.

These targets are considered realistic even though the demand for wireless services will be high, as there is likely to be somewhat a demand lag in emerging markets compared with developed country markets. In addition, to achieve these targets levels of spectrum allocation means securing the digital dividend (after the switchover to digital television) which will not be an easy or straightforward process given the number of policy and consumer issues needing to be resolved in many countries markets.

5.6.4 Determining preferred spectrum bands for allocation of new spectrum

Criteria for assessing preferred spectrum bands

In developing a methodology for recommending the spectrum bands which ought to be released by governments and regulators in the Asia Pacific region in the future for wireless broadband, it is firstly important to highlight that not all spectrum is created equal. One megahertz of spectrum in a particular frequency band is not the same value as one megahertz in another band.

Figure 16: Country suggest allocation targets for wireless spectrum until 2020
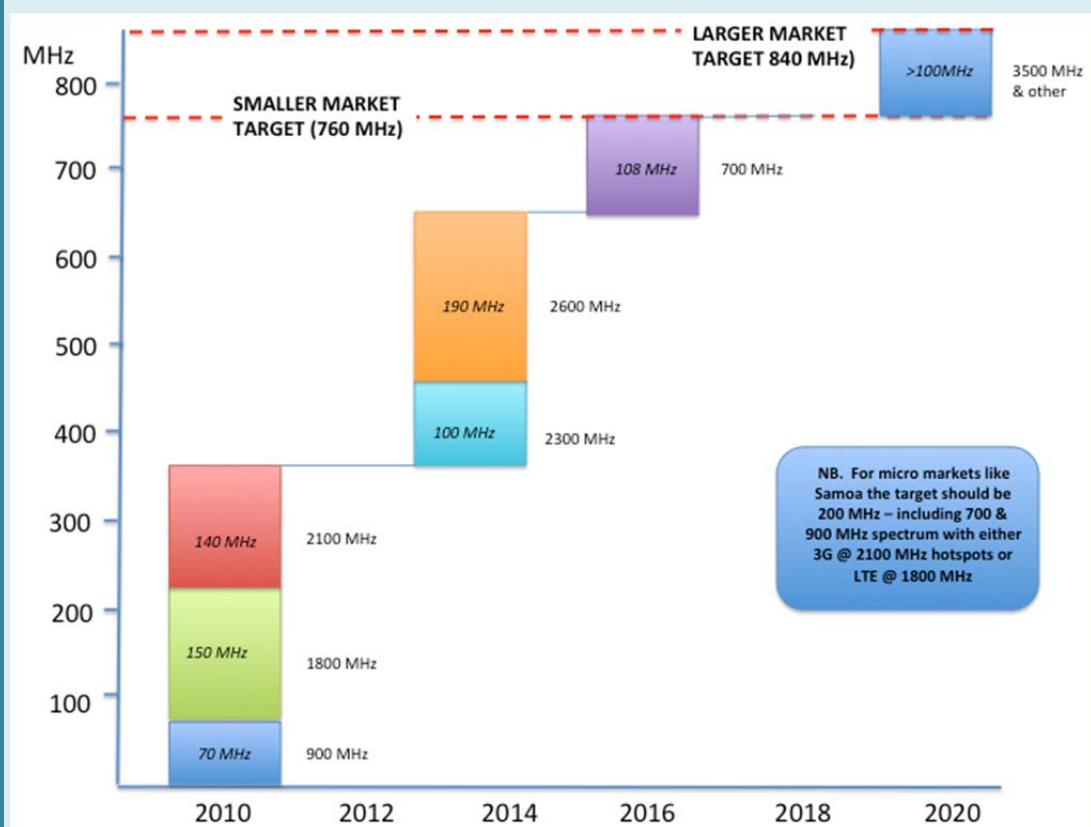
Source: ITU

As the value of spectrum bands can differ in numerous technical, operational, and regulatory aspects, the criteria for assessing preferred spectrum bands should include:

i. signal propagation characteristics (which are not changeable);

ii. whether the spectrum band is allocated internationally (or regionally) for a particular use. For example, in relation to cellular mobile use, such spectrum bands are designated in accordance with a World Radiocommunications Conference (WRC) and ITU or regionally via for example the APT (Asia Pacific Telecommunity);

iii. availability of network equipment and consumer devices (including handsets). This is often dependent on completion of technical specifications – for example by the 3GPP[47];

iv. availability of suitable bands for uplink and downlink transmissions (assuming the band is to be used for FDD) or a large contiguous spectrum block if the TDD use is proposed;

v. whether the band is cleared (or can be cleared easily) of incumbent users[48]; and

vi. need for coordination or other complex negotiations with other users and neighbouring countries (e.g., lease negotiations between satellite and terrestrial licensees and/or near border areas).

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[47] The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations, to make a globally applicable third generation 3G mobile phone system specification within the scope of the IMT-2000 project of ITU. 3GPP specifications are based on evolved GSM specifications. 3GPP standardisation encompasses Radio, Core Network and Service architecture. See www.3gpp.org

[48] If the spectrum is not clean of other users (including squatters), then the cost of clearing incumbent users, and/or dealing with interference needs to be taken into account.

Elaboration of certain preferred spectrum criteria

In relation to signal propagation characteristics (which are not changeable), the particularly favourable propagation characteristics of spectrum below 1 GHz mean that it is often referred to as "beachfront" spectrum.

These lower frequency bands have better intrinsic spectrum propagation than spectrum in higher bands and as such provide signal coverage over larger geographic areas, including in adverse climatic conditions and in difficult terrain. Operations in these bands also provide superior penetration of buildings, vehicles, and other physical obstacles.

In contrast to higher frequency bands such as the 3G and 2.6 GHz bands, lower frequency bands provide "excellent" propagation characteristics and make them ideal for delivering services – both for voice and wireless data – in all areas. To achieve equivalent coverage, a licensee that holds spectrum in a higher frequency range generally must construct more cell sites at greater cost than a licensee with its primary spectrum holdings in a lower frequency band. Because fewer cell sites (and their associated infrastructure like towers etc.) are needed, building-out networks at 900 MHz (and in the future say at 700 MHz) can be achieved at significantly less Capex to the operator and therefore lower cost to consumers. Opex costs are also likely to be significantly lower as well.

On the technical side, in contrast to lower-frequency bands, the 2.6 GHz band has below average signal propagation in terms of distance and in-building penetration. Importantly, because transmissions at 2.6 GHz do not travel as far as signals in the bands below 1 GHz, licensees must construct more cell sites.

The comparative prices paid for spectrum in lower and higher frequency bands in various auctions and in secondary market sales in various market highlight the differential value. For example, in the US, AT&T received only USD 0.17 per MHz per population in 2007 in return for its 2.6 GHz spectrum holdings while it was willing to pay between 5 to 18 times that figure (i.e. between USD 0.87 to USD 3.15 per MHz per population) to acquire both at auction and in the secondary market, spectrum in the 700 MHz band.

In relation to whether the spectrum band is allocated internationally (or regionally) for a particular use, the spectrum identified for IMT-2000 by the various WRC include those frequency bands detailed in Table 6.

Table 6: IMT-2000/4G frequency spectrum bands

Frequency Band	Bandwidth	Inclusion Decision
450-470 MHz	20 MHz	WRC-07
698-806 MHz (ITU Region 3)	108 MHz	WRC-07
806-960 MHz	154 MHz	WRC-2000
1710-1885 MHz	175 MHz	WRC-2000
1885-2025 MHz	140 MHz	WARC-92
2110-2200 MHz	90 MHz	WARC-92
2300-2400 MHz	100 MHz	WRC-07
2500-2690 MHz	190 MHz	WRC-2000
3400-3600 MHz	200 MHz	WRC-07

Source: ITU-R M.1036-3 and project analysis

Concerning the availability of network equipment and consumer devices (including handsets), the relative availability of network infrastructure and equipment is one key determinant of a spectrum band's value which requires more explanation.

Consequently, international "mature" spectrum bands - for example, the GSM bands (900 and 1800 MHz), or W-CDMA (2100 MHz bands) bands where there are multiple vendors offering network infrastructure and equipment, are typically more valuable than undeveloped or new spectrum bands where the future availability of network infrastructure and consumer devices is dependent on extensive research and the cost-intensive design, testing, and production of new components and facilities.

Over time, as an "ecosystem" of equipment manufacturers and technology vendors emerges in a particular band the spectrum in that band becomes more valuable. This is because demand and supply generates the necessary equipment and infrastructure for that band, the cost of deployment declines, and the skillsets and experience required for optimal deployment increases[49]. Flexible standards which are spectrum band agnostic, software defined radio and advances in microprocessors mean that the development time of such eco-systems is being compressed.

Preferred spectrum bands now and over the next five years

Masterplan Preparation Insight 14: The focus here is new spectrum bands (beyond the 850, 900, 1800, 2100 MHz etc.) being allocated for wireless broadband. If all of these bands are not being fully utilised given the availability of affordable equipment, handsets etc. the full allocation of such bands should be the first priority.

To determine the optimal new spectrum bands (i.e. outside the existing 900, 1800, 2100 MHz bands etc.) in markets in the Asia Pacific region through to 2020 applying the key criteria for assessing preferred spectrum bands to the key cellular mobile spectrum bands which are now available and likely to be available over that period. Against those criteria, the scores on the preferred spectrum are detailed in Table 7.

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[49] Even the value of mature spectrum may come under threat as technology requirements such as the need for larger spectrum blocks (e.g. for LTE) may mean that current key spectrum bands in the 850 and 900 MHz bands are less preferred than 700 and 1800 MHz bands for example.

Table 7: Analysis of preferred spectrum bands for markets in the Asia Pacific region up to 2020

Criteria	Possible cellular mobile spectrum bands							
	700 MHz	850 MHz	AWS[50]	1500 MHz	2300 MHz	2600 MHz	3300-3500 MHz & Other	3800 MHz & Other
(i) Signal propagation characteristics (which are not changeable)	1	1	3	2	4	5	5	5
(ii) Whether spectrum band is allocated internationally (or regionally) for a particular use	2	1	5	4	2	2	4	4
(iii) Availability of network equipment and consumer devices (including handsets)	2	2	2	3	2	2	3	3
(iv) Availability of paired bands for uplink and downlink transmissions (assuming the band is to be used for FDD) or a large contiguous spectrum block if the TDD use is proposed (or single TDD band)	1	3	5	4	1	1	2	2
(v) Whether the band is cleared (or clean) of incumbent users	4	3	4	4	2	2	3	3
(vi) Need for coordination or other complex negotiations with other users and neighbouring countries	1	1	2	1	2	1	2	2
TOTAL	11	11	21	18	13	14	19	19

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[50] Advanced Wireless Services, also known as UMTS Band IV is used in the United States and Canada. It utilises a pairing of 1700 and 2100 MHz.

The scoring of the assessment in Table 7 is summarised in Table 8.

Table 8: Scoring of possible future spectrum bands for wireless broadband

TIER	Spectrum Band	Score (IDEAL score is 6)
Tier 1	700 MHz	11
	850 MHz	11
Tier 2	2300 MHz	13
	2400 MHz	14
	1500 MHz	15
Tier 3	3300 – 3500 MHz	19
	Other (3.8 GHz etc.)	19
	AWS (1700/2100 MHz)	21

Unsurprisingly the 700 and 850 MHz bands were the highest ranking spectrum band to be allocated in the future for wireless broadband use. Having said that, the 850 MHz this spectrum band is relatively small (depending on the extended GSM bands) and its channel sizes are narrow, and as such going forward the 700 MHz is, therefore, preferred for wireless broadband.

It should be highlighted any listing of any preferred bands for allocation needs to be considered in a holistic way. This is because the radio frequency plan of a cellular communication system revolves around two principal objectives, namely coverage and capacity. Coverage relates to the geographical footprint within the system that has sufficient radio frequency signal strength to provide for a call/data session while capacity relates to the capability of the system to sustain a given number of subscribers. In most systems, including 4G LTE systems, both capacity and coverage are interrelated. To improve quality some coverage and capacity has to be sacrificed, while to improve capacity, coverage will have to be sacrificed.

As such it is recommended that regulators clear and offer spectrum which comprises a mix of coverage and capacity. This can be done by using two frequency bands (e.g. 700 MHz and 2600 MHz).

Importantly all major preferred spectrum bands have either been included in the Global Certification Forum (GCF) certification scheme for LTE devices or will soon be included[51].

Additional preferred spectrum bands for use as 'spectrum insurance'

Given the growth of wireless services globally, it is possible that the demand for wireless broadband services may be underestimated. There is even a bold view expressed by one major mobile operator that all spectrum below 5 GHz will be devoted to wireless broadband within five years[52]. Certainly if the Ericsson vision of more than 50 billion connected devices[53] is correct then more spectrum than any regulator is proposing globally will be required. Therefore, continual reviews of spectrum demand should be included in any national wireless broadband masterplan and carried out at periodic intervals accordingly.

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[51]   See www.globalcertificationforum.org/WebSite/public/LTE_CERTIFICATION_2100_AND_2600_MHz.aspx

[52]   See comments of Mr Brian Miller, General Manager, Spectrum management and Policy, Telstra regulatory affairs, at the ACMA Radio Communications Conference 2011, Sydney, 26 May 2011.   Press reports available at www.theaustralian.com.au/australian-it/telecommunications/telstra-forecasts-mobile-broadband-spectrum-needs/story-fn4iyzsr-1226063451605

[53]   See Ericsson, White paper, More than 50 billion connected devices, February 2011.

5.7 Spectrum pricing

Report ITU-R SM.2012-3, Economic aspects of spectrum management, published in September 2010 details the experiences of eleven countries with spectrum fees and pricing and describes the different economic approaches for spectrum management activities based on new experiences of administrations. It also includes the factors to be taken into account in an international comparison of fee levels, as well as guidelines on methodologies for the establishment of a spectrum fees formula and fees system.

The report is intended for use by administrations of both developing and developed countries in formulating strategies on economic approaches to national spectrum management as well as the financing of spectrum plans. In addition, the report presents an analysis of the benefits of strategic development and the methods of technical support for national spectrum management. These approaches not only promote economic efficiency but can also promote technical and administrative efficiency.

Spectrum assignment methods covered in this report include non-market and market-based assignment approaches that include transferable and flexible spectrum rights.

There are three main regulatory reforms that encompass economic aspects of spectrum management:

- **deregulation**: relaxation of rules governing spectrum access;
- **delegation**: transferring of certain spectrum management functions from government to the private sector; and
- **pricing mechanism:** ensuring economically efficient use of spectrum.

5.8 Spectrum auctions

> **Masterplan Preparation Insight 15:** Partnering with the network operators and the sector generally to facilitate economic growth rather than seeing sector as a revenue raiser is critical. Governments and regulators should ensure a reasonable return on investment.

5.8.1 Overview

The economic value of spectrum is well realized since radio services and their applications form a key input into nearly every sector of a modern economy. It is therefore incumbent on governments to essentially appropriate objectives when allocating spectrum by placing it in the hands of those who are able to create the greatest value. Efficient allocation of the spectrum resource is evidently the key.

In order to generate competition between spectrum licensees for the provision of telecommunication services, efficient allocation can usually be achieved by licensing spectrum to whoever values it most. Auctions achieve efficient allocation, and generate a sizable amount of revenue for government. Efficient allocation and maximum revenue generation go hand in hand so long as steps are taken to promote competition. These steps include clarity in the provision of rights and obligations for licensees, healthy competition, a spectrum regulator that acts in a predictable manner, and the avoidance of spectrum hoarding. Even where governments pursue revenue as an objective, it is important not to lose sight of the efficiency of spectrum use.

Auction formats and rules may vary depending on:

- the spectrum available for award and the range of potential competing uses for that spectrum;
- the likely extent of competition for spectrum (including the mixture of strong and weak bidders); and
- the impact of spectrum allocation on competition amongst network operators in downstream markets for mobile services.

Globally there is significant variation in the legal and policy frameworks for spectrum auctions. Generally, revenue maximisation with no other consideration is not the approach taken by governments. If this were the case, the allocated spectrum would have been concentrated in the hands of only a few operators, potentially even a monopoly operator. Clearly such an approach would be highly detrimental to consumers.

Evidently, even those governments that are interested in revenue raising through spectrum allocation do not treat revenue as the only objective. Where raising revenue is a consideration it is usually modulated by other factors, such as the need to preserve effective competition in downstream markets.

5.8.2 Best practice for spectrum auctions

There are some clear messages for best practice for spectrum auctions.

Key objectives - efficiency and competition

The aim should be to maximise the overall benefit to the consumers or the society at large from the use of spectrum, instead of generating maximum revenue from spectrum sale in the short-run. Efficient allocation of the radio spectrum should be the primary objective for spectrum allocation.

Efficient allocation of spectrum through a competitive process such as an auction inevitably raises revenue.

Revenue maximisation objectives are fine when competition is protected

The revenue maximisation objective should still work assuming that downstream competition in services derived from spectrum is effective. Otherwise, this would lead to outcomes in which operators could gain market power downstream, raising prices for consumers who have little choice of alternative providers. In such a case, revenue would ultimately be generated at the expense of consumers and would not enhance the social value generated by spectrum.

The two objectives of revenue maximization and efficient allocation are closely aligned where competition for spectrum is strong. In such a case, measures that promote efficiency typically increase revenue and vice versa.

Pre-requisites for spectrum allocation efficiency and revenue generation

Certain features of a spectrum award process need to be in place irrespective of whether a government objective is to achieve efficient spectrum allocation or maximise revenue. These features encourage participation in auctions and enhance competition for spectrum:

- a clear definition of the rights and obligations associated with spectrum licences;
- consistency and predictability in the actions of spectrum regulators, with a commitment to stick to announced plans to avoid a 'hold-up' of licensees;
- predictability of any on-going charges made during the course of a licence; and
- complete and consistent rules of any auction process.

The case of low competition for spectrum

In the case where competition is low, the objectives of revenue maximisation and efficient allocation may diverge.

When it is only the existing operators that constitute the strong bidders with weak or non-existent competition from others for a new spectrum band, it is important to have realistic expectations about revenue and not to create auction rules that generate significant risks of grossly inefficient outcomes.

5.9 Utilising scarce spectrum/refarming under-utilised bands

5.9.1 Digital TV and the digital dividend

Given that digital TV is many times more efficient than analogue, the shift from analogue to digital TV transmission is freeing up the scarce radio spectrum. Globally, this freed up spectrum, called the digital dividend, is offering a unique opportunity to expand the availability of wireless broadband services to a much wider range of subscribers. The spectrum for terrestrial television is therefore being reorganised to accommodate newer and more efficient digital TV services especially below 1 GHz (470 to 862 MHz) that is ideal for covering rural areas[54]. The digital dividend has the potential to enhance the broadband coverage many times over.

The digital dividend could also provide crucial low-frequency spectrum for the deployment of next-generation rural broadband, and steps to make this spectrum available for use by different technologies are welcomed. The cost of deploying next-generation wireless broadband to rural areas could be reduced drastically if sufficient digital dividend and 'refarmed' spectrum was made available for wireless broadband.

Refarming the analogue TV spectrum could stimulate the wireless broadband market and bring dramatic improvements to mobile broadband, digital dividend spectrum could help wireless broadband to complement or compete with fixed-line broadband. Digital dividend spectrum is, and should be a key driver for LTE deployments worldwide. Indeed, not only is it a unique opportunity for wireless operators to capture much needed additional spectrum for LTE deployment, it also offers the potential to accelerate the availability of broadband services to customers in traditionally underserved markets.

Additionally, because this spectrum has such attractive technical features, it can help ensure that operators can address the broadband demand – including services in the home – in a very cost-effective manner.

UHF bands IV and V (470 – 862 MHz) for TV have the potential for providing the digital dividend. There are recommendations on policy, regulation, technologies, network planning, customer awareness and business planning for the smooth introduction of DTTB (Digital Terrestrial Television Broadcasting) and MTV (Mobile Television).

Given the dominant position of cellular mobile services now and wireless broadband in the future, the need for additional spectrum in the 700 MHz band (i.e. the digital dividend) with the migration to digital TV is particularly profound for countries anticipating strong growth in data traffic. For these countries, spectrum will be required sooner rather than later.

> **Masterplan Preparation Insight 16:** Countries that do not currently have UHF television, and hence the 700 MHz remains relatively unused and available for early allocation, should allocate such spectrum early, say by mid-2013 to secure early wireless broadband benefits.

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[54] In so far as the ITU Radio Regulations are concerned, the frequency band 698-790 MHz has allocation for IMT in Region 2 and in nine countries in Region 3 namely Bangladesh, China, Rep. of Korea, India, Japan, New Zealand, Papua New Guinea, Philippines and Singapore. The band 790-862 MHz has allocation for IMT in Region 1 and 3. Having said that, WRC-12 made allocations for Region 1 in the band 694-790 (refer to the Footnote ADD 5.3XX in the Final Acts for the WRC-12).

5.9.2 Refarming rural spectrum allocations

In some country markets, key spectrum is allocated exclusively for the provision of rural services. Where key spectrum is used exclusively for this purpose there is a risk that the spectrum will be allowed to lie 'fallow' and is unable to be used in urban areas. Where this occurs, the utilisation of spectrum should be immediately reviewed. This is a regulatory issue and not a technical one. This lack of reuse is highly unusual in global terms and if this spectrum were available for use, it would have an immediate impact on both affordability (lower costs especially in urban areas) and the quality of service.

5.10 Future bands (e.g. 'white spaces') and use of satellites for wireless broadband

5.10.1 White spaces

White spaces refer to unused electromagnetic spectrum between analogue TV channels. White spaces therefore exist naturally between used channels, since assigning transmissions to immediately adjacent channels will cause destructive interference to both.

Originally set up as protection/guard bands to eliminate interference between channels, these frequencies were traditionally used for wireless microphones used in theatres and other venues. These are now being planned for wireless data services, dubbed 'Super Wi-Fi'.

White space signals travel further and more easily through walls and barriers than other forms of wireless communications technology, such as Bluetooth and Wi-Fi, and this spare capacity could be used to enhance broadband services in rural areas.

Certain administrations are working towards the creation of a 'geo-location database' – in other words, live information on which frequencies are free to use in the vicinity of a given location. This will ensure that white space devices do not interfere with TV broadcasts and other wireless technologies operating on similar bands.

Devices will use white space technology in much the same way as they currently use Wi-Fi. The major difference is that devices operating on white space spectrums will need to be checked against the new database before roaming on to a signal.

According to Ofcom the white spaces could be available on an unlicensed basis where the total capacity on offer would exceed that currently available for 3G mobile network services[55]. Ofcom states that white spaces are currently lying vacant all around us, and efforts are being made to try to harness this capacity without causing harmful interference to existing users of the spectrum.

Electrical and electronics engineers in the US published the IEEE 802.22 standard for using white spaces. The standard defines the unlicensed use of frequencies between TV channels in the VHF and UHF bands. The IEEE said its standard could be used around the world, especially in rural areas and developing countries where there tend to be more vacant TV channels[56]. Harnessing unused broadcast frequencies could accelerate the roll-out of low-cost wireless broadband and the following details makes it an attractive option for broadband provision:

- Technology trials are on to explore how the unused TV spectrum can be harnessed for wireless broadband services.
- White space connections can achieve a practical range of up to 10 km, compared with just 4 km for typical wired ADSL connections. The cost of deployment will be significantly less than fibre over long distances, which makes it ideal to connect un-served rural locations.

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[55] www.cio.in/news/ofcom-improves-wireless-broadband-white-space-technology-168812011

[56] www.computerweekly.com/news/2240104991/Development-firm-TTP-trials-white-space-technology-in-wireless-broadband-link

- Unlicensed white space spectrum does not have the very high cost burden of licensed spectrum, which enables high-performance, cost-effective commercial systems to be rolled out quickly using existing and emerging mass-market silicon platforms.

- Key technical challenges will be to guarantee there is no perceptible interference with licensed users.

- This will require a sophisticated central database approach with heuristic learning and feedback mechanisms similar to those found in Internet search engines that learn from the information users request and select.

- The technology aimed at harnessing white spaces is expected to offer broadband speeds of around 16 Mbit/s, but has the potential to be much faster.

- The White Space Coalition (members include Microsoft, Google, Dell, HP, Intel, Philips, Earthlink, and Samsung Electro-Mechanics) expects speeds of 80 Mbit/s and above, and 400 and 800 Mbit/s for white space short-range networking.

5.10.2   Use of satellites for wireless broadband

Around the mid-1990s, packet-switching technology and the Internet – both of which led directly to the development of broadband technology, satellite and terrestrial networking enabled multimedia traffic, voice/video/data/fax, to be carried over 'converged' data networks. The terms Voice Over IP (VoIP) and IP telephony were introduced to describe how circuit switched voice signals were converted into data packets for transport on IP networks. Since the opportunities for convergence of data, voice and multimedia (video) on the same network are now offered by IP, satellites, with their inherent strength to cover mass geographical coverage are offering a sound solution. Satellites are therefore seen as powerful transmission tools for broadband applications.

High throughput satellites using spot beam technology and frequency re-use have the potential to drastically reduce costs and to become engines of growth for the satellite industry. This is a great encouragement for regulators word-wide to embrace satellite dissemination as a part of their broadband strategy, especially for rural coverage.

A new breed of satellites has been developed to address the growth in demand for broadband connectivity. These satellites, known as high throughput satellites (HTS), represent a paradigm shift in satellite technology. In HTS platforms, there is a high level of frequency reuse thanks to the adoption of spot-beam technology, which ultimately makes it possible for operators to deliver services comparable to terrestrial services in terms of pricing.

As shown in Figure 17, spot beams illuminate smaller areas (100s of km^2 instead of 1000s) with a coverage that looks more like a honeycomb/cellular pattern. Frequency reuse drastically increases overall capacity, providing faster speeds to smaller dishes and resulting in service up gradation at lower costs.

Figure 17: Spot beam technology with frequency reuse for high throughput satellite

Source: ITU
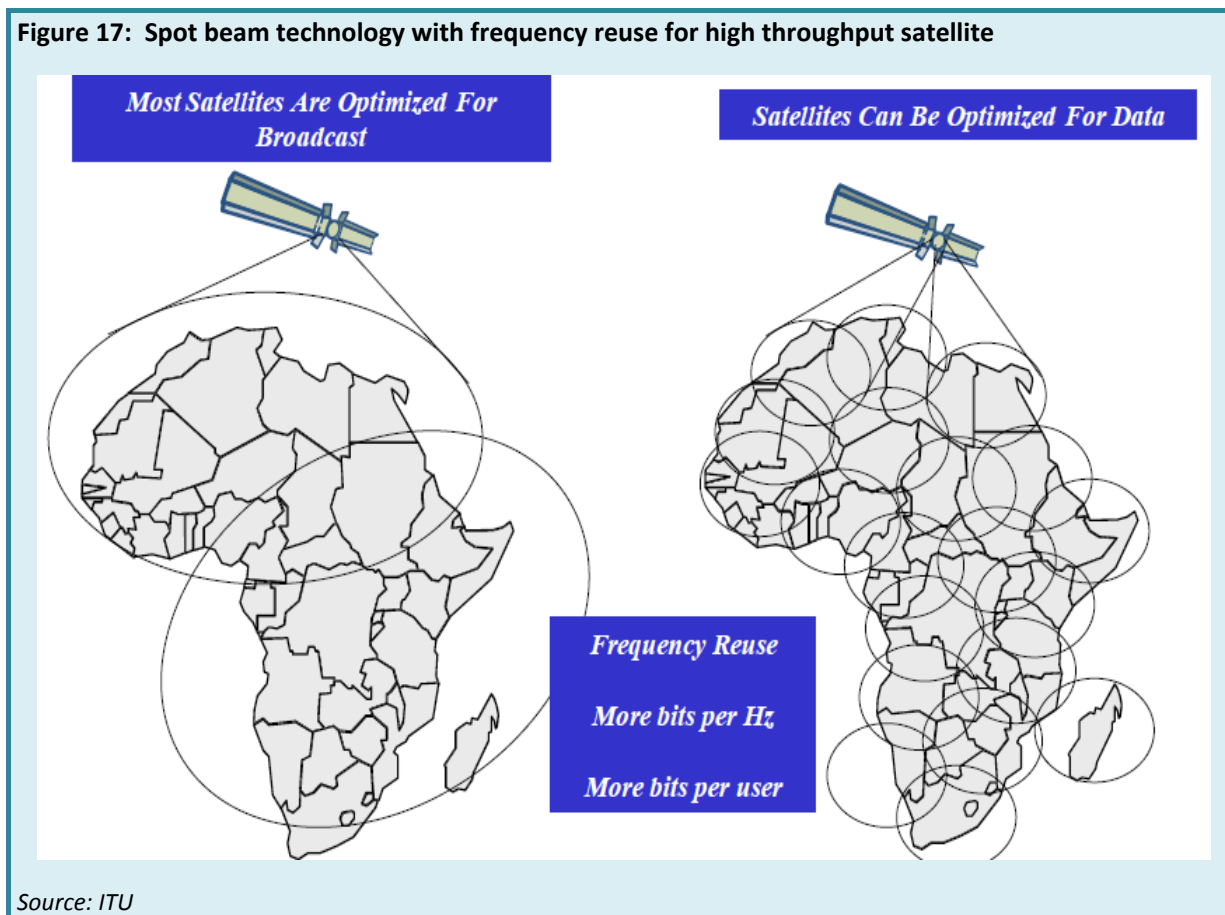
5.10.3   Why is there a digital divide?

The cost of rolling out terrestrial technology dramatically increases with population dispersion. The cost of providing fibre for the last 10-20 per cent of the population is many times higher than for the central areas. Current fibre deployment in Europe, for example, reaches less than 1 per cent of market penetration, according to the European Competitive Telecommunication Association[57]. Speeds are decreasing rapidly with the distance for terrestrial means.

Satellites have no 'last mile issues' and are reliable when natural disasters/acts of terrorism disable other communications. Service to remote locations and mobile sites i.e. ships, trains, planes and vehicles, is possible and remote sites can be deployed very quickly with satellite access. Satellites can accelerate the availability of high-speed Internet services in developing countries.

High Throughput Satellite (HTS) capacity provides a benefit for a Ka band network in the order of about 100-to-1 as compared to the conventional Ku band satellite, and has the potential to bring down the service provision cost by a similar magnitude.

The HTS demand for core applications is likely to exceed 530 Gbit/s by 2019 (Figure 18).

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[57]   www.ectaportal.com/en/

Figure 18: HTS demand for core applications
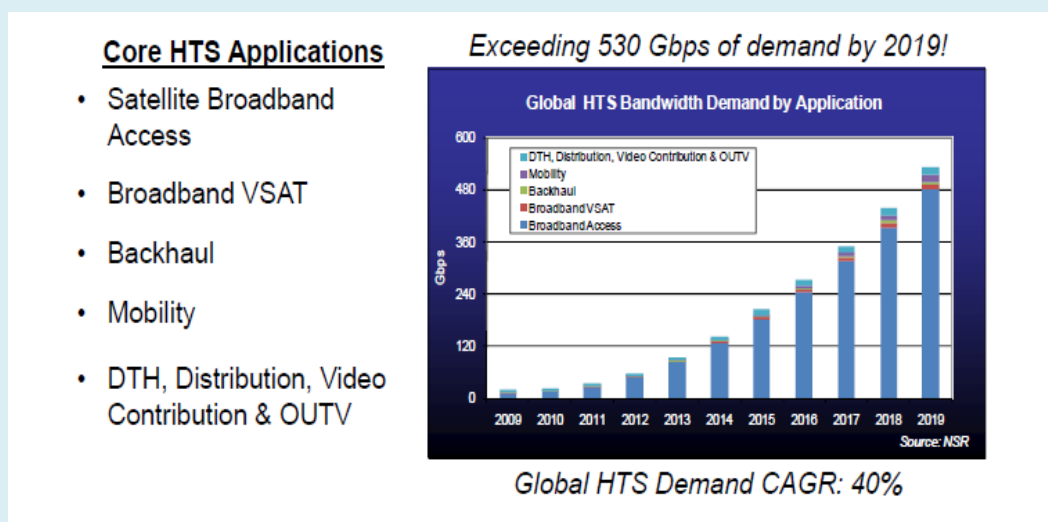
Source: ITU

5.11 Need for cross border co-ordination for use of fixed and land mobile systems

Appendix H gives detailed guidance on how cross-border co-ordination can be managed. For certain countries this may be a key part of their wireless broadband masterplan.

6 Technologies / innovations in wireless broadband

6.1 Overview

While an exploration of all technologies and innovations in wireless broadband is beyond the scope of these wireless broadband masterplan guidelines and is the subject of many other ITU publications[58], some of the key issues which need to be assessed in relation to technology issues are detailed in Box 7.

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[58] Some of these include (i) Recommendation M.1457-10 (06.11)- Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000) (www.itu.int/rec/R-REC-M.1457/en); (ii) REPORT ITU-R M.2038 – Technology Trends (www.itu.int/pub/R-REP-M.2038-2004) and (iii) WRC-07 RESULTS AND IMPACT ON TERRESTRIAL BROADBAND WIRELESS ACCESS SYSTEMS, John Alden for ITU 8th Global Symposium for Regulators, Pattaya, Thailand, 11-13 March 2008 (www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/discussion_papers/John_Alden_session4.pdf)

Box 7: Selected important questions about the technology available

- Is GSM or another technology widely deployed in the country?
- Does the country have W/CDMA infrastructure and services? Or CDMA infrastructure and services?
- Has there been deployment of 3G and/or LTE technology in the country? If so, is TDD or FDD LTE technology preferred? Which release of 3G development is available in the country?
- What stage of the technology development path is the country in? (2GSM>GPRS>EDGE>3GSM> W-CDMA>HSDPA>HSUPA>HSPA+>LTE)
- What percentage of the population is able to be covered by each different wireless broadband standard? E.g. 96 per cent GSM, 65 per cent W-CDMA, 10 per cent HSPA+
- What is extent of the country's backhaul capacity? Is the majority of backhaul capacity microwave based or is it fiberized?
- What is the country's total international bandwidth capacity? Is the country's international bandwidth capacity diversified? Via submarine cable, or satellite? How many access points (cable landing stations) to international bandwidth are there?
- Do operators encourage network offloading techniques? If so which techniques are used or encouraged?
- What access does the country have to satellite broadband services?
- Has there been investment in satellite broadband regionally?

While ITU advocates a technology-neutral approach, this does not mean that no particular mobile technology is preferred over another. What a technology-neutral approach does is ensure that operators are not hamstrung into continuing supplying a particular service when cheaper and more efficient substitutes are available. When selecting a mobile technology and deploying it in a designated frequency band, it is important to consider whether the said technology is harmonised. Harmonised technology ensures interoperability and cheaper telecommunications equipment. This section will address the issues relating to technology harmonisation and canvas the major mobile technologies available. Figure 19 illustrates a comparison of the different access technologies.

Figure 19: A comparison of different access technologies
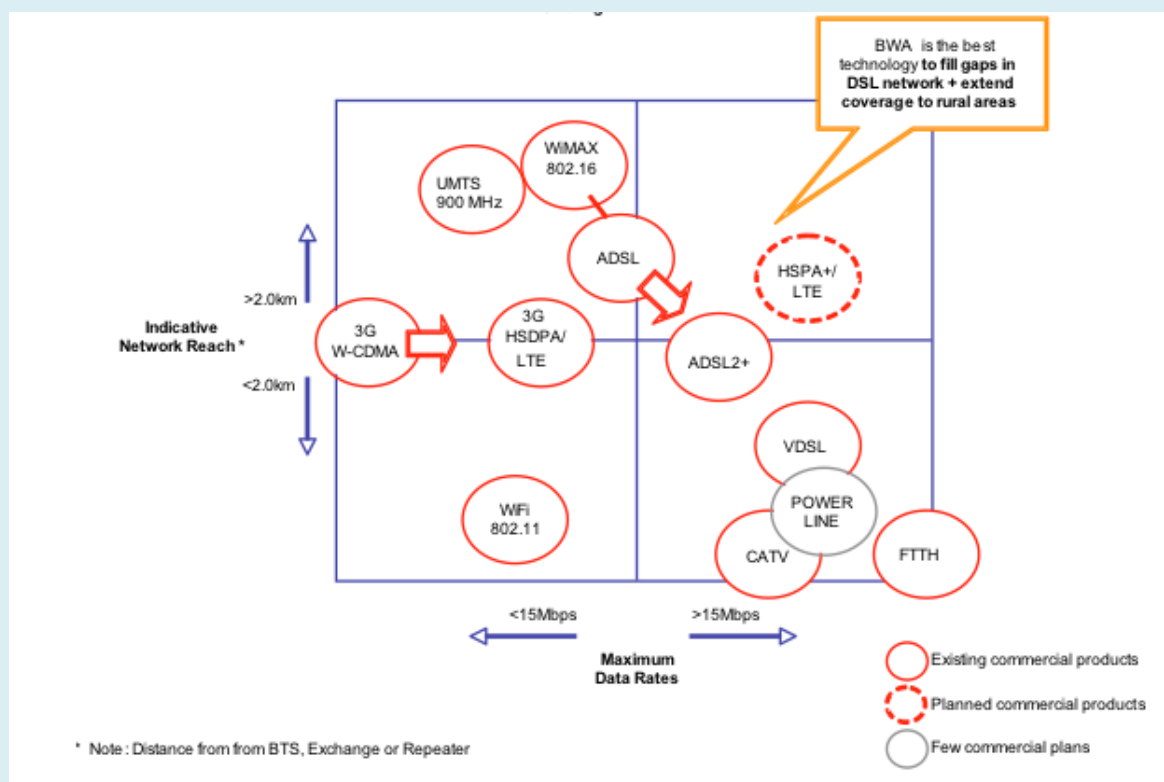
Source: Windsor Place Consulting, 2010

6.2   GSM and W-CDMA

6.2.1   GSM

Key wireless services operate on a range of bands reflecting either vendor support or other factors. Spectrum allocations are consistent with the majority of countries worldwide (GSM operates mainly on 900 and 1800 frequency bands, and CDMA operators in China on the 450 MHz).

In the transition from 2G to 3G a number of standards have been developed, which are categorized as 2.5G. These are add-ons to the 2G standards and mainly focus on deployment of efficient IP connectivity within the mobile networks. Data access is provided by General Packet Radio Service (GPRS) and offers throughput rates of up to 40 kbit/s. As of Q2 2010, there were over 4.42 billion GSM subscriptions[59].

6.2.2   W-CDMA/HSPA

W-CDMA is the access scheme defined by ITU to be the main technical platform for UMTS or third generation mobile services. W-CDMA services are to operate within the following frequency bands: 1920 MHz – 1980 MHz and 2110 MHz – 2170 MHz. ITU had selected W-CDMA as one of the global telecom systems for the new IMT-2000 3G mobile communications standard. In W-CDMA interface different users can simultaneously transmit at different data rates and data rates can even vary in time. W-CDMA is capable of delivering up to 384 kbit/s in outdoor environments and up to 2 Mbit/s in fixed indoor environment. W-CDMA is currently at release 9.

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[59]   www.gsacom.com//downloads/charts/GSM_market_share_global.php4

High Speed Packet Access (HSPA) is a set of technologies that allow W-CDMA operators to run their networks at broadband speeds. Peak downlink and uplink throughput is at 14.4 and 5.7 Mbit/s, respectively. HSPA+, which harnesses MIMO (multiple in, multiple out) enables peak data rates of up to 42 Mbit/s.

The roadmap for wireless technology evolution from GSM to W-CDMA to LTE services is shown in Figure 20.

Figure 20: Wireless technology roadmap
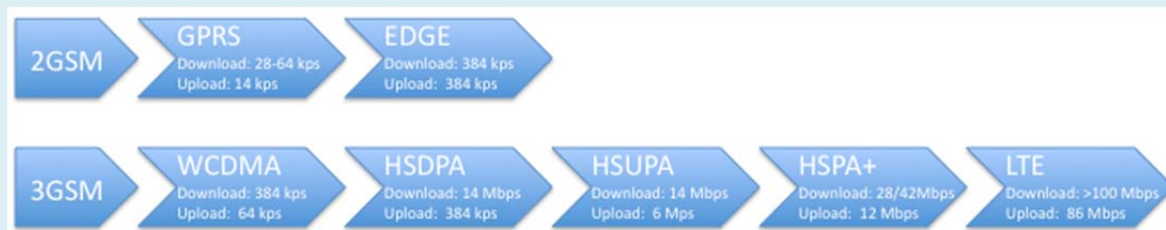
Source: Ericsson and Qualcomm, 2009.

As of January 2012, there are reportedly 241 HSPA+ network commitments with 187 HSPA+ networks having been launched. Total subscribers amount to 822.4 million (including 469 million HSPA subscribers)[60].

As case studies show (Box 8), the cost of 3G coverage with UMTS900 can save operators between 50 to 70 per cent of mobile network costs (including Capex and Opex) versus UMTS2100. UMTS900 can more cost effectively provide 3G and mobile broadband services in rural and regional areas. There is also an added benefit of improved indoor coverage.

Box 8: Case study: Optus UMTS900 network

In 2008, Australian carrier Optus launched the world's largest UMTS900 network. With almost 1 000 base stations, the network covers over 96 per cent of the population. Given Australia's population distribution, fixed broadband penetration is relatively low and demand for wireless broadband high. Optus recognised this as an opportunity to compete with Telstra's national coverage and decided to expand its 3G network to enable high-speed data services. Optus had launched a UMTS2100 network in 2005, but UMTS900 was recognised as more cost effective for rural areas.

Deployment
Recognising the potential of UMTS900 to economically extend coverage to low-density areas, the regulator (ACMA) quickly approved the deployment. From a strategic perspective, Optus chose to focus on areas where GSM usage was lower. It used its existing network infrastructure, overlaying coverage on existing 2G base stations and in urban areas, co-locating with UMTS2100.

Results
The use of UMTS900 technology enabled Optus to deliver a better quality network at a lower cost, with each base station covering a greater geographical area than UMTS2100 due to reduced path-loss. Using UMTS2100 to achieve the same coverage outcomes would have cost at least AUD 800 million. With UMTS900, capital expenditure was reduced to less than AUD 500 million. In addition, the deployment delivered unexpected benefits to the 2G service. When re-farming the 900MHz spectrum, Optus' focus on site optimisation led to increased 2G performance in some cases.

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[60] www.gsacom.com/news/gsa_fastfacts.php4

6.3   WiMAX

WiMAX is the popular name of IEEE802.16 standard. It serves as both a fixed and wireless access technology. Coverage of 50 km and capacity of around 70 Mbit/s is a reality with this technology. It is, however, important to note that the capacity offered over long distances is only a fraction of the maximum capacity, and WiMAX as access technology is offered in distances of 5 to 10 km. WiMAX is thought of by some as a good complementary / competitive infrastructure to traditional broadband. Another important aspect is that 70 Mbit/s will only be achieved if frequency bandwidth of 20 MHz is allocated and assigned by the local authorities. Many regulators will probably assign smaller frequency bands to the potential WiMAX operators. A competing technology to the mobile version of WiMAX (IEEE.802.16e) is LTE.

By mid-2011, global subscribers (including fixed WiMAX) were said to number approximately 20 million. Mobile WiMAX subscribers are expected to rise to 59 million by 2015[61].

6.4   Satellite

> **Masterplan Preparation Insight 17:** Satellites are very important in providing wireless broadband to those customers who are away from terrestrial wireless broadband networks. Consideration of satellite networks to provide wireless broadband services to rural and remote users as well as providing backhaul links to local wireless broadband networks is a necessary part of a wireless broadband masterplan. Hybrid broadband networks with terrestrial and satellite components are a subject of intense study in ITU and other forums.

Satellites are valuable part of the broadband infrastructure strategy. They are able to provide ubiquitous connectivity and are very well suited for areas which are either underserved or unserved by terrestrial networks. They are able to augment and combine with terrestrial network and once launched can accelerate the availability of high-speed Internet services in such areas. As an added bonus, satellite communication does not have any last mile issues and can provide a high degree of reliability in the event of disasters etc.

There has also been recent technological innovation in relation to satellite technology, similar in a way to wireless broadband communications. The new generation of satellite broadband systems known as HTS (High Throughput Satellite) have a number of new features:

- spot beam technology, where switchable beams illuminate much smaller areas (100s of km^2 instead of 1000s km^2);
- beam coverage forms a honeycomb / cellular pattern with frequency reuse;
- this concept of frequency reuse drastically increases overall capacity;
- use of Ka band leads to smaller antenna dishes; and
- satellite broadband services with frequency reuse, faster speeds and smaller dish antennas in Ka band drive down the costs to a much lower level.

6.5   LTE / LTE-Advanced

LTE is the latest standard in the mobile network technology evolution that follows from the GSM/EDGE and UMTS/HSPA network technologies. It is a project of the 3rd Generation Partnership Project (3GPP)[62].

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[61]   www.fiercewireless.com/story/wimax-forum-trumpets-20m-global-subscribers/2011-08-17 & www.eweek.com/c/a/Enterprise-Networking/Mobile-WiMax-Subscribers-to-Reach-59-Million-by-2015-Report-442841/

[62]   The 3rd Generation Partnership Project (3GPP) is collaboration between groups of telecommunications associations, to make a globally applicable third generation 3G mobile phone system specifications within the scope of the IMT-2000 project of ITU. 3GPP specifications are based on evolved GSM specifications. 3GPP standardization encompasses Radio, Core Network and Service architecture. See www.3gpp.org and for LTE specifically see www.3gpp.org/article/lte

The current LTE specification Release 9 provides downlink peak rates of at least 100 Mbit/s, an uplink of at least 50 Mbit/s. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time division duplexing (TDD). The next step for LTE evolution is LTE Advanced and is currently being standardized in 3GPP Release 10.

In October 2010, ITU accepted and officially designated LTE-Advanced as an IMT-Advanced (4G) technology, while the 3GPP published Release 10 of the LTE standard in March 2011 and has frozen the set of features for LTE Advanced[63]. One of the major reasons for aligning LTE with the call for IMT-Advanced is that IMT conforming systems were candidates for the spectrum bands identified at WRC07. Such moves made LTE a truly global standard compared with the fragmented regulation of earlier wireless standards. Commercialisation of LTE-Advanced systems are expected in the 2014-15 timeframe.

In January 2012, ITU confirmed the status of LTE-Advanced and Wireless MAN-Advanced technologies were both granted IMT-Advanced Technology status by ITU (Box 9).

Box 9: ITU announcement on 4G technology

In January 2012, LTE-Advanced and Wireless MAN-Advanced technologies were both granted IMT-Advanced Technology status by ITU. After undergoing evaluation by ITU and meeting the specification requirements, the technologies are now officially accorded 4G status[64].

ITU is responsible for setting mobile technology standards worldwide. The approval signifies the next stage in the evolution of LTE, which is set to deliver vast improvements in speed and efficiency.

The new technology will be significantly faster than 3G, with speeds above 100 Mbit/s. It will also make more efficient use of radio-frequency spectrum, meaning higher data transfers will be possible with a lower bandwidth requirement. The new technology will facilitate the growing demand for data transfer over mobile networks.

According to the GSA, as of January 2012 there are 226 LTE network commitments in 76 countries and 59 pre-commitment trials. There were approximately 3.6 million subscriptions at this time. By 2015, an expected 744.2 million will subscribe to LTE[65].

6.6   Why LTE is the preferred technology following 3G / W-CDMA

LTE is acknowledged as the next step for a superior mobile broadband experience, targeting capacity and data rate enhancements to support new services and features requiring higher levels of capability and performance. LTE will enhance more demanding applications such as interactive TV, mobile video blogging, advanced games and professional services with significantly higher uplink and downlink data rates, supported by the necessary network architecture and technology enhancements.

Most importantly as shown in Figure 21, LTE is more spectral efficient than other air interface technologies. As such, LTE reduces the cost per GB delivered which is essential for addressing the mass market, and supports a full IP based network and harmonisation with other radio access technologies.

In a survey of major operators, the great majority (some 88 per cent) indicated that they were already considering LTE upgrades for their next generation networks, with likely deployments in 2011 and beyond. This is consistent with the fact that LTE has had rapid global acceptance with 49 commercial LTE networks having been launched in 29 countries, some 226 operators in 76 countries are investing in LTE

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[63]   3GPP is setting the Release 11 requirements in 2011 with its completion scheduled for late 2012.

[64]   ITU, 'IMT-Advanced standards announced for next-generation mobile technology', media release, 18 January 2012

[65]   http://www.gsacom.com/news/gsa_fastfacts.php4   &   http://www.electronics-eetimes.com/en/lte-subscribers-to-account-for-10-percent-share-by-2015.html?cmp_id=7&news_id=222910064

and there are 59 pre-commitment trials in 17 more countries. It is also expected that at least 119 LTE networks will be in commercial service in 53 countries by the end of 2012[66].

Figure 21: Summary of downlink spectral efficiencies for various air interfaces and antenna schemes
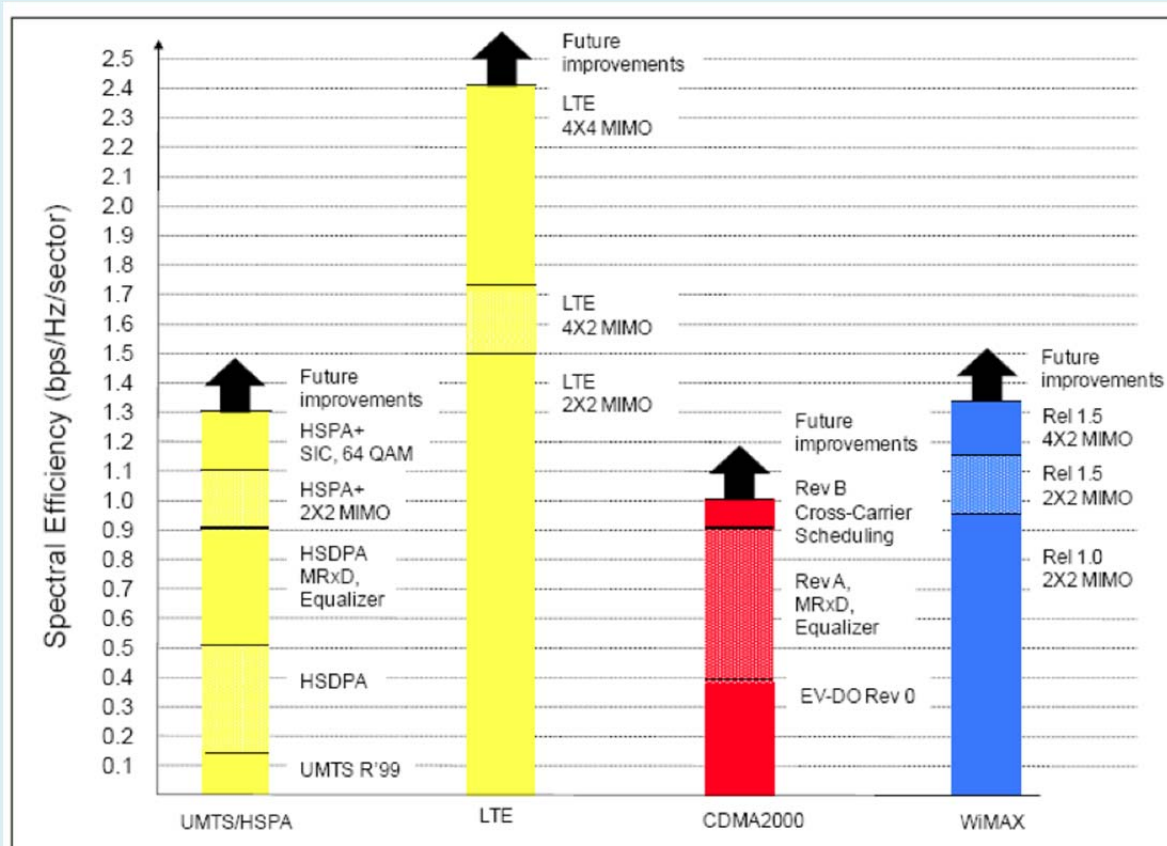
Source: 3G Americas, MIMO and Smart Antennas for 3G and 4G Wireless systems, Practical Aspects and Deployment Considerations, May 2010, page 58

A possible complication in relation to voice over LTE seems to have been resolved with the first VoLTE call on commercial network (namely Verizon) in the world occurring in February 2011. It is expected that VoLTE should be widely available globally in 2013.

More broadly, there are a number of steps to provide optimal voice services on LTE networks and devices. Firstly, the current approach is to use dual radiophones that utilise the 2G networks in the mobile phone for all voice calls. Secondly, voice calls will be provided over LTE with circuit switch fall back (CSFB) to the 2G networks where necessary (e.g. no coverage). Lastly the ultimate approach will be to adopt Single Radio Voice Call Continuity (SR VCC) for VoLTE, which uses an IP Multimedia Subsystem (IMS) system for call anchoring and handover and is based on a third party call control mechanism. This allows a mobile phone with an on-going voice call to transition to the circuit-switch domain in the event of loss of LTE coverage. An IMS-based SRVCC provides QoS control, flexible charging, and better user experience. The options for addressing on LTE networks are detailed in Figure 22.

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[66]   GSA, GSM/3G Market/Technology Update, 5 January 2012.

Figure 22: Options for addressing voice on LTE
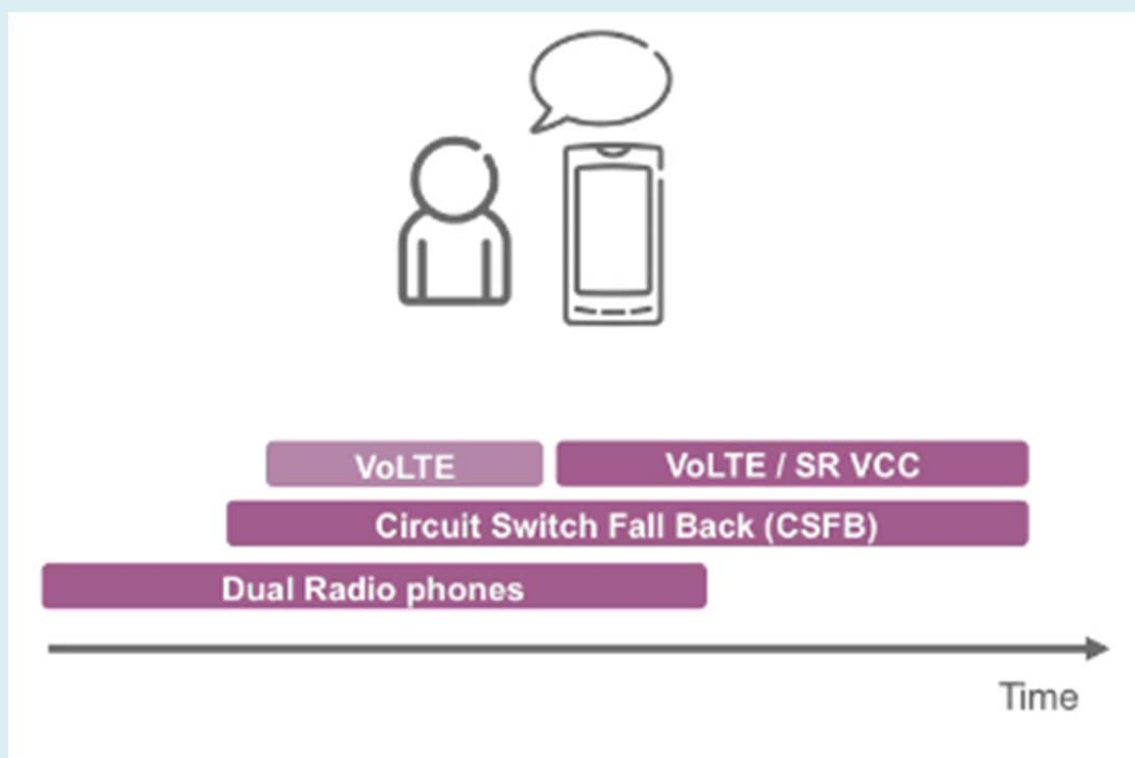
Source: Informa Telecoms & Media and Ericsson, LTE Early Launch Strategies: Who and Why? Webinar, 21 June 2011

6.7   Wireless offloading for wireless broadband

As wireless data and broadband services grow, the regulator should seek to safeguard the quality of wireless services by encouraging operators adopting network offloading techniques. Such flexibility ought to be included in any wireless broadband masterplan. These include Wi-Fi offloading, Femtocell deployment, smart repeaters, and distributed antenna systems[67].

Network offloading should be facilitated by the wireless broadband masterplan as it alleviates capacity constraints and is a sensible allocation of spectrum resources. Specifically, the ability to utilise open access spectrum (such as 2.4 and 5 GHz) to support those small number of cell sites/locations which face congestion has considerable merit. An analysis of the potential use of off-loading techniques should form part of the needs and valuation models for additional spectrum.

We examine the two major network offloading techniques in detail focusing Wi-Fi and Femtocell deployment. These techniques are used in urban environments where typically the demand is the greatest. It is suggested that Wi-Fi is preferred ahead of femtocell deployment especially if optical fibre network infrastructure exists in that required locations.

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[67]   For the purposes of this paper we do not assess another data offload technique/technology known as Integrated Mobile Broadcast (iMB). iMB which a mobile wireless technology that enables broadcast of content has not been broadly embraced and is unlikely to be utilised in Asia.

6.7.1 Wi-Fi off-loading

Offload can be defined as utilising complementary technologies for delivering data originally targeted for 2G, 3G and future 4G networks. Wi-Fi technologies[68], which were ubiquitous in computing, have been utilized extensively in that role. More specifically the proliferation of smartphones and tablet computers with built in Wi-Fi is driving the demand for, and therefore the expansion of, public Wi-Fi networks.

There are three types of Wi-Fi off-loading (Figure 23) depending on the degree of coupling between the cellular mobile and Wi-Fi networks, namely:

- **Tight coupling**. This utilises 3GPP Enhanced Generic Access Network (EGAN) architecture as it specifies rerouting of cellular network signalling through Wi-Fi access networks. This makes the Wi-Fi access network as a de-facto 3GPP RAN. This technology is better known as Unlicensed Mobile Access (UMA). In the beginning, it was targeted to improve indoor coverage for the voice service in 2G networks. In 3GPP later releases GAN architecture was extended to cover also 3G packet data protocols, and hence is now referred to as EGAN architecture.

- **Loose coupling**. 3GPP has also specified an alternative approach called Interworking Wireless LAN (IWLAN) architecture and it is a solution to transfer IP data between a mobile device and operator's core network through a Wi-Fi access. In the IWLAN architecture, a mobile device opens a VPN/IPsec tunnel from the device to the dedicated IWLAN server in the operator's core network to provide the user either an access to the operator's walled-garden services or to a gateway to the public Internet. With loose coupling between the networks the only integration and interworking point is the common authentication architecture. Currently, it is not possible to initiate a call on a Wi-Fi network and continue the call on a 3G network.

- **No Coupling**. This is the most straightforward way to offload data to the Wi-Fi networks. It results in there being a direct connection to the public Internet. It means that there is no need for interworking standardisation. For mere web access there is no added value to route the data through the mobile operator's RAN and core network.

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[68] Wi-Fi is the marketing-friendly term for the 802.11 family of wireless networking standards. It got its start with 802.11b with a data-transfer speed of 11 Mbit/s. Next came 802.11g at 54 Mbit/s, then the present fastest standard, 802.11n has a top speed of 450 Mbit/s.

Figure 23: Wi-Fi offloading (referred to as HNB-GW) implementation
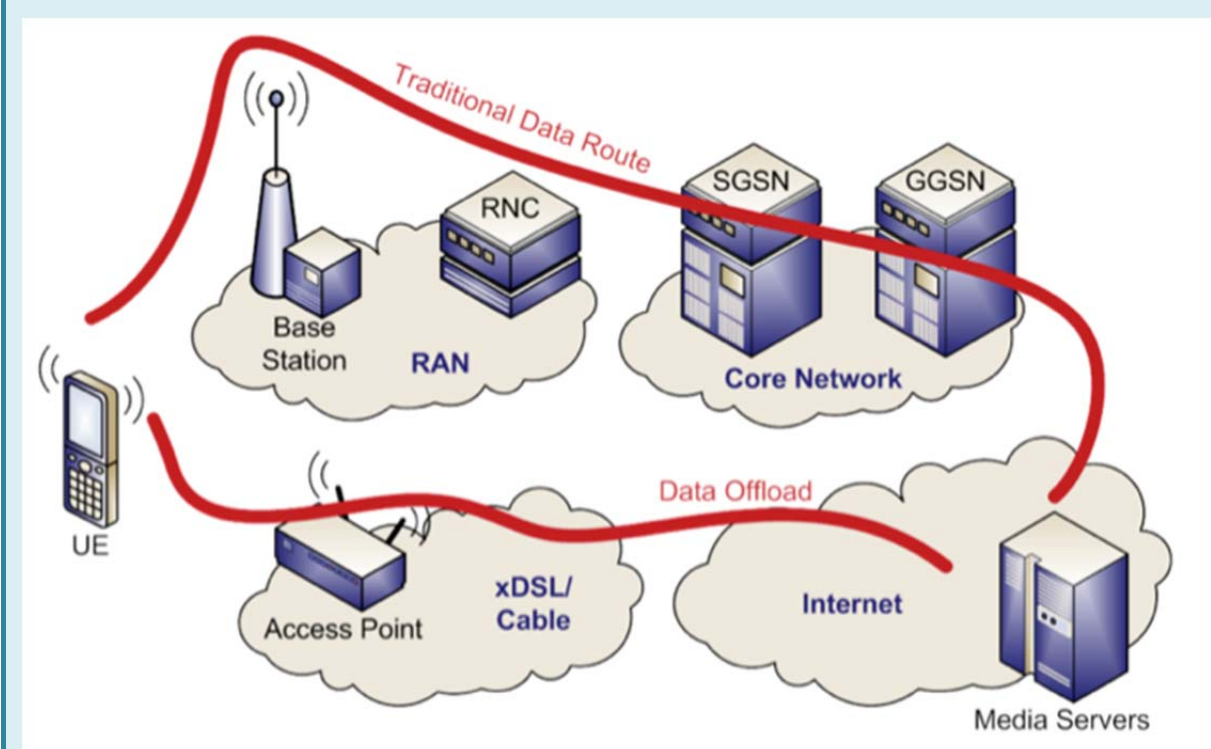
Source: Coleago, 2010

6.7.2   Future developments

While Wi-Fi is being deployed, it is still in its evolution phase and technological developments are ensuring that it will play a key role in future offloading solutions. Several enabling features are in development phases, namely (Box 10):

i. **Secure Authentication**: This authentication is inbuilt into SIM cards and will mean that subscribers are granted exclusive access to their operator's Wi-Fi.

ii. **Wi-Fi Handover**: This will enable the seamless transition between different Wi-Fi cells.

iii. **3G/4G Handover:** This is a key development area and is being actively pursued. It will enable the automatic transfer of devices from 3G/4G networks to Wi-Fi.

The introduction of these enhancements will have substantial effects on the utility and versatility of Wi-Fi as a means of alleviating capacity constraints. It will also add to the appeal of this product.

Box 10: Future Wi-Fi developments

Integrated off-loading[69]

Three of the four largest US mobile operators (namely AT&T, T-Mobile and Sprint) are testing technology from startup WeFi (see www.wefi.com) that lets them point subscribers' smartphones to private and public Wi-Fi networks whenever practical. If the US operators formally adopt the programme, consumers should see a change in the way their handsets navigate networks. That, in turn, should translate into savings in the number of downloads consumers use and hence costs.

The system announced in March 2011 is called WeANDSF – a name which combines WeFi's name with the words Access Network Discovery and Selection Function. It consists of three parts: (i) a software client for consumers' phones, (ii) a global database of Wi-Fi networks and (iii) a control panel that operators can use to specify how, when and where devices on their networks should connect to outside Wi-Fi.

WeFi is also shipping the WeANDSF system to operators outside the US. Deutsche Telekom is currently trialling it and operators in East Asia have also expressed interest in the technology.

Wi-Fi developments

Going forward there are also developments in Wi-Fi technology. These are principally driven the Wireless Gigabit Alliance (WIGig)[70]. WiGig Alliance has developed a unified specification for 60 GHz wireless technologies that will provide multi-gigabit wireless connectivity among PCs, consumer electronics and handheld devices.

Two new versions of Wi-Fi are under development namely 802.11ac (at 1 Gbit/s) and 802.11ad (at 7 Gbit/s). 802.11ac uses 5 GHz spectrum solely while 802.11ad also uses the much higher 60 GHz spectrum. The 802.11ac standard gets its speed by extending 802.11n with wider RF bandwidth (up to 160 MHz), more MIMO spatial streams (up to 8), multi-user MIMO, and high-density modulation (up to 256 QAM). On 31 May 2011, Qualcomm announced its first tri-band Wi-Fi chipset, the Atheros AR9004TB. This chipset is capable integrate multi-gigabit performance of in-room 60 GHz band with a seamless handoff to 2.4 GHz and 5 GHz band Wi-Fi[71]. While the use of the high frequency range will limit the range of the 802.11ad technology for Wi-Fi hotspots the seamless handover will permit high speed data transfers in localised zones.

6.8   Possible deployment of femtocells

Femtocells are low-power wireless access points (a home Node B) that operates using licensed spectrum to connect standard mobile devices to a mobile operator's network using xDSL, fibre or cable broadband connections (Figure 24). While not strictly used for wireless broadband services they are included here for completeness. Femtocells address:

- Coverage and quality of service issues (i.e. providing "five-bar" voice quality). To reduce customer churn, operators offer femtocells to improve voice coverage indoors, with the aim should reduce that churn and improve the customer experience.

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[69] Adopted from Forbes. http://blogs.forbes.com/elizabethwoyke/2011/04/22/automatic-wi-fi-offloading-coming-to-u-s-carriers/

[70] See www.wirelessgigabitalliance.org

[71] See www.qca.qualcomm.com/corporate/content.php?nav1=119&news=324

- Higher mobile data capacity (where Wi-Fi is not used). Such higher capacity and data net throughputs are ultimately limited by backhaul to the femtocell in most cases[72].

Figure 24: Femtocell (referred to has HNB-GW) implementation
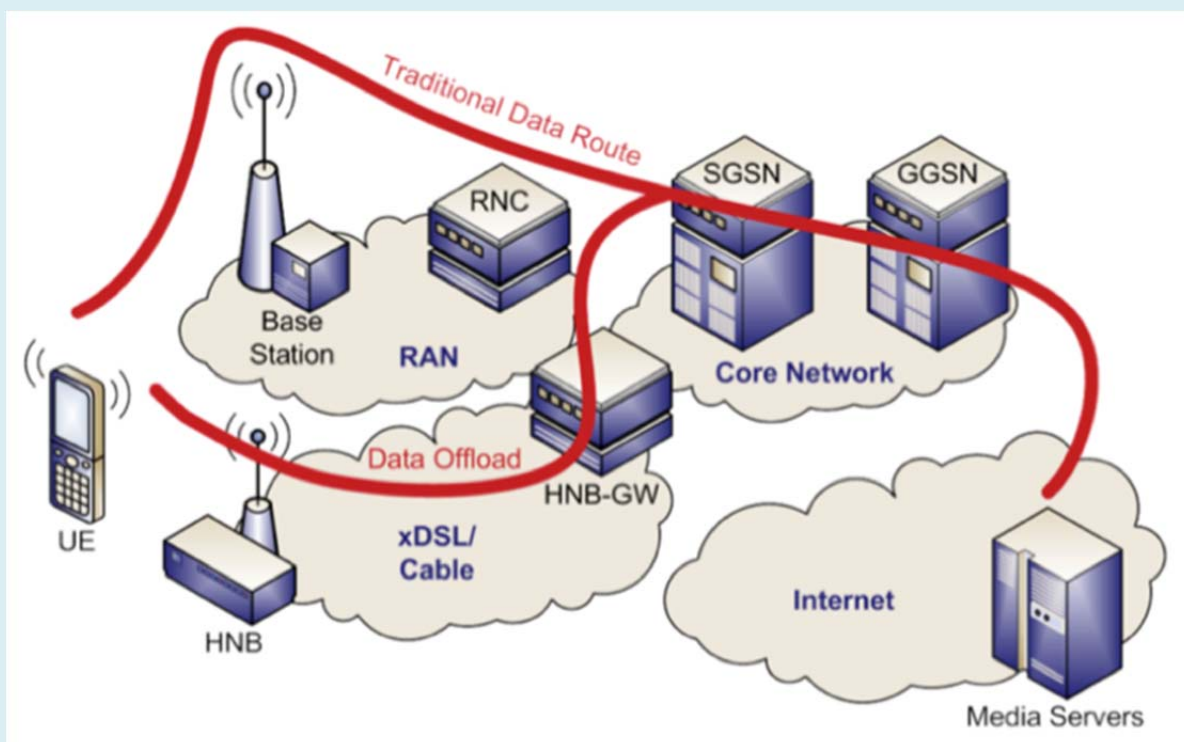
Source: Coleago, 2010

Currently, according to industry commentators, Informa, as at the end of March 2011, 20 mobile operators have already deployed femtocells in their networks and 34 operators have committed to their launch[73].

Operators' femtocell business models are expected to evolve from using it as a technology to fill a structural gap in network strategies to a base from which to generate new revenue streams. The revenue opportunity will arise as femtocells start to take a role into the connected home and office environments, controlling different devices using different services, content and applications (assuming such services can be monetorised). Femtocells also form the first part of the new self-organising network (SON) and transform the potential of small cells by providing a practical preview of core LTE functionality.

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[72] In mid-2009, the Femto Forum released a research paper which found that the cost savings associated with offloading as little as 1.4 GB of HSPA data per month via a femtocell from macro cellular network would justify an operator offering a subscriber a free femtocell.

[73] Informa, Learning from the Femtocell and Wi-Fi Pioneers: Best practice in operator go-to- market strategy, Webinar, 18 May 2011.

It is recommended that the possible future deployment of femtocells be supported by policy by:

    i.   ensuring the femtocells (which are in essence a Home Node B) are not chargeable as a separate cell site under the spectrum regulations; and

    ii.   developing practical approaches to lawful interception of traffic generated on femtocells.

6.9 Frequency arrangements based on technology selection

Recommendation ITU-R M.1768 contains the methodology for calculation of spectrum requirements for the future development of the terrestrial component of IMT-2000 and systems beyond IMT-2000. This generic methodology can be used for differing markets for a range of cellular system architectures. Specifically, the technical process of estimating spectrum requirements for mobile communications has to be based on four essential issues namely:

- definition of services;
- market expectations;
- technical and operational framework; and
- spectrum calculation algorithm.

It is likely that greater allocations of spectrum to wireless/cellular services will be required in order to support the efficient provisioning of services (at affordable prices) and to support the economic growth. While the optimal timing to secure additional spectrum needs to be ascertained, the extended time period in which to facilitate new spectrum releases will always make this difficult to do perfectly.

For countries with high cellular mobile penetration and growing broadband (including wireless broadband) penetration, it will difficult to independently forecast the likely demand for wireless and wireless broadband services with any certainty (this problem will be compounded if PSTN teledensity is failing). For the longer term (up to 2020), these Guidelines prefer an approach of assessing the overall spectrum requirements in a manner consistent with ITU-R Report M.2078 (2006)[74].

For countries with developed or close to developed markets, minimum spectrum requirements should be benchmarked against other developed countries. For instance studies from the United States, United Kingdom, and Australia provide pricing information that may be used for this purpose.

For some countries, achieving the target levels of spectrum allocation may mean securing the digital dividend (after the switchover to digital television), which may not be an easy or straightforward process given the number of policy and consumer issues that need to be resolved.

6.10 International connectivity

There is a need to ensure low cost, low latency, high-speed international connectivity. For some countries this will be a short-term priority depending on the current capacity of international gateways. How connectivity is achieved will depend on how developed the telecommunications market is, the availability of technology and the country's geography. For example, island nations will be forced to consider submarine cables, whereas landlocked nations will be forced to consider terrestrial cables. For isolated countries, international connectivity is paramount.

Where a country's backhaul infrastructure is unlikely to be sufficient to meet medium to long-term adoption broadband targets, additional capital expenditure will be required to address connectivity. Policymakers need to address considerations relating to both local and international connectivity. These factors underscore the importance of establishing an effective interconnection/open access regime as well as stimulating the wholesale market in order to reduce market inefficiency and improve competition.

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[74]   See ITU-R Report M.2078 Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced, 2007.

If a country is landlocked, this could mean that end users are dependent on foreign wholesalers providing domestic operators with international access. A possible means of addressing this problem is through greater reliance on mobile satellite service (MSS) systems.

For developing countries, international connection costs may pose a major problem and adversely affect the quality of service for end users. Regulators should assess the number of operators using the international connectivity gateways and consider whether there is sufficient competition or if additional operators are required. In addition, governments should initiate a consultation process with operators in order to determine whether a more open access regime to international gateways is a desirable option.

Consistent with ITU broadband policy recommendations[75], there are considerable economic benefits and a high degree of sector support for greater backbone deployment (especially using optical fibre) to support future wireless broadband[76].

Given affordability issues, an infrastructure sharing avoids the duplication of expensive backhaul networks is preferred. Such sharing can be achieved as other country markets have done by instituting a quality regulatory framework including via a transparent and effective interconnection regime.

7 Stimulating the demand for wireless broadband: Facilitating applications and content

In some markets in the Asia-Pacific region, locally created content has not yet reached a stage equal to that of fully developed markets. For some countries, due to their smaller population size, it is likely that they will rely to some extent on content generated in connected markets. However, in general, even developing markets have a significant range of content services with a variety of applications. While there may be much to be done in terms of encouraging the development of new and existing content, content providers have shown that they have the ability to deliver innovative products that will greatly enhance the population's access to information and other services.

Some of the key questions/issues which should be posed in relation applications and content issues are detailed below in Box 11.

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[75] See ITU, *Trends in Telecommunication Reform 2012, Smart Regulation for a Broadband World*, Geneva, 2012.

[76] Infrastructure development is a key component of ASEAN's ICT policy and is recognised as necessary for the successful implementation of the other strategic thrusts. Member States have committed to establishing an ASEAN Broadband Corridor. This will be achieved through a number of means including:

- Identifying and developing locations in ASEAN Member States which offer quality broadband connectivity;
- Enabling seamless usage of broadband services and application across the ASEAN region to improve connectivity and services; and
- Promoting the diversity of international connectivity among ASEAN Member States.

An ASEAN Internet Exchange Network has also been scheduled for completion. This will be achieved by establishing a regulator / operator forum to develop a platform to enable intra-ASEAN internet traffic and facilitating peering amongst ASEAN internet access providers to reduce costs and improve latency.

Box 11: Initial questions/issues on the applications and content market

- How large is the content creation industry in the country? Are there estimates available of the value of the industry or the number of firms engaged in content creation?

- Are courses available at education institutions which aid or encourage content creation and provide the skills necessary for this? Has there been significant investment in this area?

- Is the ICT sector the recipient of any investment from the perspective of labour training and job creation? And are there appropriate competency and skill measures and standards/certifications in the country?

- Does the government subsidise local content production? Or is the local content industry viable in itself?

- Are there regulatory measures which stimulate content production? For example, domestic content quotas.

- What content is available in local languages (i.e. beyond English etc.)?

- Does the government have a direct presence in online services? What is the government's score in the e-government evolution?[77]

- Does the government encourage development in the key content areas of mobile network services, online games, online advertising and e-commerce?

Masterplan Preparation Insight 18: The need to have applications and content in local languages cannot be over-emphasised. To secure very high wireless broadband penetration rates means that customers must be able to access relevant and useful applications in languages which they can understand.

7.1 State of play of global content and applications market

Governments around the world are focused on encouraging the creation of content, and the first step involves providing greater access to broadband services. With a greater proportion of the population connected online, there is a greater demand for content and a bigger market to develop for. As access grows, countries can continue to develop a base of key online services, such as electronic funds transfer, online government services, e-health, and a range of cultural and educational content.

For example, the goal of e-education and awareness is to achieve an inclusive electronic and online society in which everyone has access to information services. One of the key aims of government might be to ensure that every child leaving school is familiar with computers and are scientifically literate. Some governments are collaborating with the private sector and local communities to establish multimedia classrooms and small computer laboratories in high schools. Furthermore, IT learning centres, electronic resource centres and computer training centres are also being set up in colleges and universities.

Globally, there is strong online presence across a range of sectors. Different countries will be at different stages of development, and the availability and variety of content is certainly not uniform. Whereas advanced economies will have established deep content markets, for developing markets the process of expanding online interaction continues. However, there are important innovations taking place, including in the areas of government, media, tourism, entertainment and education.

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[77] E-government Web measure index measures the level of sophistication of a government's online presence based on four stages of e-government evolution: emerging presence, enhanced presence, transactional presence, and connected presence. A value of 0 indicates the lowest presence, a value of 1 the highest. Data listed for 2009 are for 2010. United Nations Department of Economic and Social Affairs and United Nations Public Administration Network.

7.1.1 Government

In many developing markets, government departments have frequently updated websites with detailed information, including major reports and studies, scheduled cabinet meetings, budget and forecasts, national accounts and information on access to government services. For non-English speaking countries there may not yet be a majority of English content, but nevertheless the Internet has facilitated a high degree of transparency in government activity and the dissemination of important information for citizens.

7.1.2 Media outlets

Many media outlets also provide internet-based news and content services. The largest circulating newspapers will typically contain a wealth of online content. Radio stations will publish daily schedules online and in may include online audio and podcasts. Even in regions that have lagged behind other countries in the use of computer-based ICT, concepts such as community radio have proven very successful, and are particularly useful for countries with difficult terrain and a dispersed and isolated population. Community radio delivers both entertainment and developmental content. Community radio stations are also now using the Internet to share digital content produced from a central location.

7.1.3 Tourism

Tourism is an important industry for many developing countries. All major hotels, resorts and tour operators will typically have websites introducing their services and providing online services to book accommodation and plan itineraries. Central tourism authorities will often provide information to tourists about accommodation, car rentals, sport, restaurants, and general information about the country and its culture. Because of the importance of tourism to the economy, this sector will often provide some of the most impressive online content.

7.1.4 Entertainment

Entertainment websites feature sports, music, movies, fashion as well as local and international artists. User-generated content in social networking sites has been increasing, and these sites, which are often community-focused, feature message boards, discussions, photo galleries and videos by locals living in various parts of the world.

7.1.5 Education

In the education sector, major universities provide detailed information, including programs and courses over the Internet. Schools are also beginning to acquire an Internet presence. Online directories and almanacs currently exist and enable the user to locate local schools, colleges, and training institutions. In addition, the results of university and board examinations are published on the Web on a regular basis.

Major colleges and universities offer several distance learning courses for students, and many have created their own courseware servers and learning management platforms. Additionally, distance-learning courses are available in selected institutions that are affiliated with universities abroad. The potential for developing e-learning as a means to expand educational opportunities is high. Providing e-learning in rural and isolated areas would increase equitable access to quality education for all.

7.2 Stimulating the content and applications sector

It is arguable that there is a circular relationship between applications/content and broadband uptake. The higher the penetration of broadband services, the more data /content rich applications consumers demand; whilst the more attractive and relevant applications / content are, the more consumers will demand broadband in order to participate in those markets.

Naturally, in regions with low internet / data penetration, policy makers should first attempt to those problems before setting out to stimulate content in a drive to increase broadband uptake.

There are a number of means through which the government can intervene in order to create an enabling environment for content production industries and ultimately drive demand for their services.

7.3 Educate content entrepreneurs

Governments can work to stimulate the domestic content sector by educating their national ICT workforce with the set of skills and outlook that are necessary for the requisite innovation and technical expertise required for the market to expand.

New courses at existing technical/educational institutions may be developed so as to encompass issues associated with applications/content. It may be necessary for the government to train teachers/trainers with a range of input skills for content production (e.g. graphic design, animation, information technology).

An example from Australia is shown in Box 12. Overseas expertise may need to be harnessed for the training of a skilled and dynamic workforce in areas such as management, finance and creative process development.

Box 12: Digital media courses at the Australian Film Television and Radio School[78]

The Australian Film Television and Radio School (AFTRS) offers a number of specialist postgraduate courses within the digital media field of study.

A 'Graduate Certificate in 3D Animation' provides "a comprehensive, specialist course designed to develop the professional skills of digital artists through production-focused learning…. [and] course provides a thorough grounding in the art of 3D animation using AutoDesk Maya software. The course offers a number of modules aimed at giving students a grounding in both the technical and business side of the 3D animation sector:

- 3D Graphics Fundamentals;
- Character Animation Foundations;
- Collaborative;
- Creative Research;
- Industry Brief;
- Introduction to Running Your Own Creative Business; and
- Key Figures in Animation

…"

The government should also be open to obtaining overseas assistance in developing appropriate competency/skill measures and standards/ certification.

7.3.1 Subsidise content production

In order to improve the supply of content, financial tools such as direct outlays and tax measures may be employed by the government. Each tool possesses unique policy design issues that must be properly addressed prior to implementation.

7.3.2 Regulatory measures

Regulatory measures provide the means to stimulate content production with relatively low direct costs to governments. For example, local content rules may provide a domestic content quota – in Australia, this was a key driver behind the early development of content production.

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[78] See www.aftrs.edu.au

As discussed in section 7.4.1, policy design issues, such as the location on the value chain where the intervention occurs and preferences for the type of content development will need to be considered.

7.3.3   Direct government action and leadership

Governments can take the lead to develop and deploy online/wireless services. If there exists good access to bandwidth and devices, online and wireless delivery can be a highly cost effective to provide information about government services and some of the services themselves in a much more equitable manner. Initiatives should not be limited to national governments: regional and local government can provide important and useful information to local residents and businesses.

Specifically, assessing the sophistication of a government's online presence based on four stages of e-government evolution namely emerging presence, enhanced presence, transactional presence, and connected presence there is considerable differences across the Asia Pacific region (Table 9).

Table 9: E-government web measure 2010 (note 1.00 is the highest)

Country	E-government web measure	Secure internet services (per million)
South Korea	1.00	1,140.4
United States	1.00	1,561.9
Canada	0.89	1,368.6
Australia	0.86	2.005.9
United Kingdom	0.97	1,594.3
Singapore	1.00	607.3
Japan	0.86	743.3
Malaysia	0.79	54.4
Germany	0.75	1,025.6
HIGH INCOME	**0.68**	**1,068.0**
Philippines	0.50	7.5
China	0.53	2.4
India	0.54	2.9
Thailand	0.51	16.6
Viet Nam	0.42	4.7
WORLD	**0.41**	**183.7**
MIDDLE INCOME	**0.37**	**11.6**
Indonesia	0.50	3.4
Cambodia	0.19	2.5
EAST ASIA AND PACIFIC	**0.22**	**4.2**
Laos	0.22	1.3
Myanmar	0.10	0.1

Source: World Bank, The Little Data Book on Information and Communication Technology, 2012

Rewards/recognition is also suggested for areas related to rural communications development, content/applications development and 'broadband readiness' disclosures for residential and commercial developments.

8 Conclusions, way forward and suggested roadmap

Globally, the early stages of the mobile broadband revolution occurred in 2006/07 as key enablers, primarily around technology, began to converge. These enablers will continue to drive mobile broadband's rapid adoption and market share gains from fixed technologies, such as DSL. As indicated by the US Federal Communications Commission (FCC) broadband wireless services are having profound economic and social consequences even in developed country markets:

"Wireless mobility has become central to the economic, civic, and social lives of … [our citizens]. We are now in the midst of a transition from reliance on mobile voice services to increasing use of and reliance on mobile broadband services, which promise to connect [our] citizens in new and deeper ways … [the] mobile wireless market will be essential to realizing the full benefits to … consumers and channelling investment toward vitally important national infrastructure. A vibrant mobile wireless market is also essential to driving innovation, not only within the mobile market itself, but also in markets – current and future – for which wireless mobility is a key enabler."[79]

Based on global statistics the number of wireless broadband subscribers has exceeded the number of fixed broadband subscribers and will continue on an explosive growth path as per current growth estimates. According to the Cisco Visual Networking Index Global Mobile Data Traffic Forecast overall mobile data traffic is expected to grow to 10.8 Exabytes (1 Exabyte=1018 bytes) per month by 2016 as shown in Figure 25.

Figure 25: Overall mobile data traffic growth 2011 – 2016

| Selected Segments	2011	2012	2013	2014	2015	2016	CAGR
Data	0.17	0.33	0.55	0.86	1.35	2.17	65%
Video	0.31	0.74	1.56	2.92	4.88	7.62	90%
File sharing	0.08	0.11	0.15	0.20	0.26	0.36	36%

Source: Cisco, VNI Report, 2012

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[79] FCC, Notice of Inquiry, Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless including Commercial Mobile Services, Docket FCC 09-67, released 27 August 2009, page 2

As the industry embraces mobile broadband, data demand on the network is increasing rapidly, and operators need to find a cost efficient way to continue providing the service. A ten-fold increase in mobile data traffic could translate to a less than 10 per cent increase in revenue for operators. LTE serves as the common migration path for all existing mobile standards to address the cost challenge (Figure 26).

Figure 26: Benefits of LTE: decoupling revenue and traffic
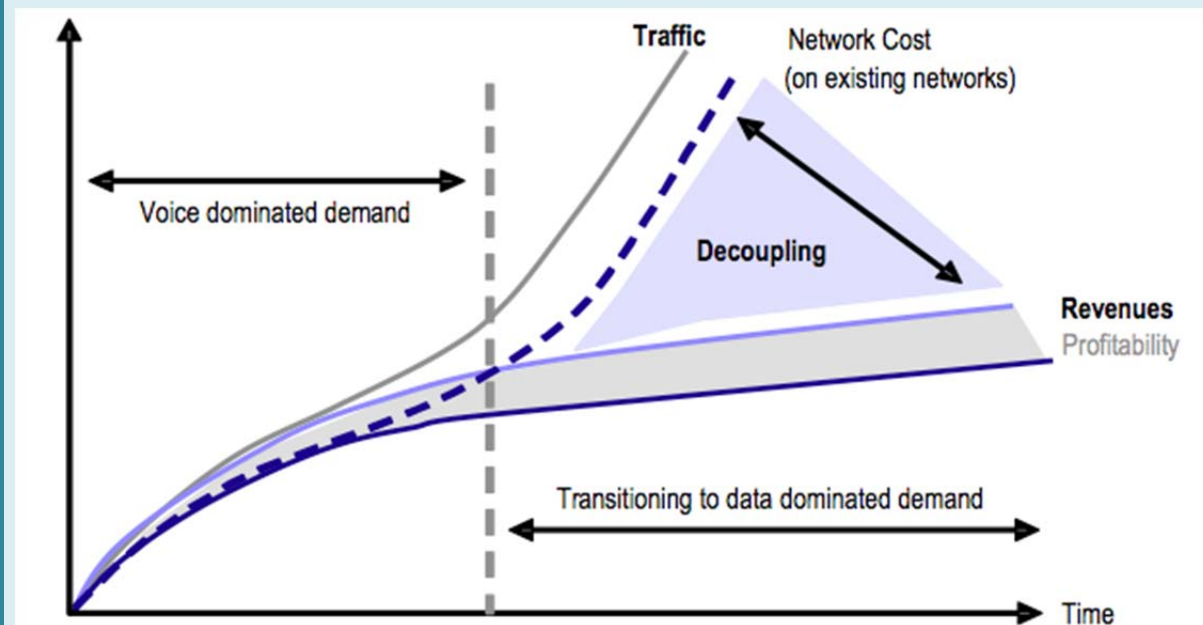
Source: UBS, 2009

8.1   Devising wireless broadband targets

Many countries have already adopted ambitious targets for broadband access. These targets cover a range of outcomes such as individual access and community access, the availability of certain technologies or coverage across a certain portion of the population. These Guidelines for the wireless broadband masterplan support the setting of targets as it provides a goal in relation to which all stakeholders are focussed upon.

For example, along with more detailed targets, governments may adopt broad wireless broadband targets along the following lines:

- **Community Access:** Communities over a certain number people should have access to broadband services.

- **Individual Access**: A certain percentage of the population should have access to broadband of X Kbit/s. Countries may adopt different target speeds for different proportions of the population.

- **Community Broadband Centres**: All communities with broadband access should have the option to establish a Community Broadband Centre.

- **School Access**: A certain number of schools or a certain proportion of students should have access to broadband.

- **Government Access**: A certain proportion of transactions between citizens and government should be conducted online.

How demanding current or proposed targets are for a country will depend on inter alia the state of existing ICT infrastructure and current penetration levels. For some countries, there will be a very large commitment of resources required in order to achieve a given target, as well as a high degree of collaboration between stakeholders.

> **Masterplan Preparation Insight 19:** The setting of those targets in general terms but especially if they go beyond those promulgated by the Broadband Commission, need to be carefully assessed and are likely to require a customised review.

A more detailed example of possible wireless broadband targets in one of the wireless broadband masterplan pilot countries is provided in Box 13.

Box 13: Example of proposed broadband access goals

The following ten goals should be considered both ambitious and achievable by a given year:

- broadband penetration should be within a certain range;
- urban broadband should have the choice of a minimum number of service providers;
- companies in central business districts should have a choice of a minimum number of service providers;
- government agencies should have broadband connections, an informative web site, responsive email access and opportunities for basic transactions such as application forms to be completed online;
- capital cities should be connected by optical fibre backbone links;
- a certain percentage of secondary schools should have a broadband connection and use it both for professional education and as part of the standard curriculum;
- hospitals and a certain percentage of clinics should have a broadband connection;
- community resource centres with a broadband connection should be established using international best practice models;
- towns or villages beyond the reach of commercial wireless broadband services should be identified as the basis for a subsidised program to support service extensions.

Source: ITU, Universal access to broadband in Nepal, 2011, page 52

It may be the case that, while the targets are achievable assuming wide network deployment, they require a substantial fall in connection fees per local SIM to lower levels in line with global pricing norms. On-going subscription for access and calls, SMS (Short Message Service) as well as wireless data pricing may also need to fall substantially. The achievement of targets may necessitate significant falls, or else demand is unlikely to exist.

8.2 Roadmap for the wireless broadband masterplan: Action items and timeline

Key milestones and actions to be included in any wireless broadband masterplan are dependent on *inter alia* the review recommended in this document including the current state of competition, as well as the state of technology and current spectrum utilisation. While Appendix B details the suggested approach where more substantial reforms are needed in order to introduce sector competition and attract new investment, if only minor policy changes 'fine-tuning' is required then the suggested approach to embody in the wireless broadband masterplan is detailed in Table 10 and Figure 27.

It includes a policy change to support technology neutrality to ensure the best use of technology and spectrum and securing the digital dividend in a short period of time so that it can be released for the use by operators (who will likely deploy LTE technology) in the near term.

Table 10: Key recommended action items if competition is adequate

Date	Action
Month 1	• Commit to technology neutrality (e.g. W-CDMA @ 900 MHz and LTE at 1800 MHz)
Month 7	• Review of additional band plans (2.3 and 2.6 GHz, etc.)
Month 10	• Introduce new telecommunications legislation / amendments as required • Refarm 900 MHz band and others if required
Month 13	• MVNO rules promulgated (if required)
Month 22	• Secure digital dividend @ 700 MHz (if required) • Consider merits of additional operators
Month 36	• Release of first digital dividend for LTE / LTE-Advanced @ 700 MHz
End of year 4	• Regional grouping commitments met (i.e. ASEAN, SAARC, etc.)
2020	• Broadband adoption targets for 2020 met

Figure 27: Recommended timeline for action where minor or fine tuning policy changes are needed
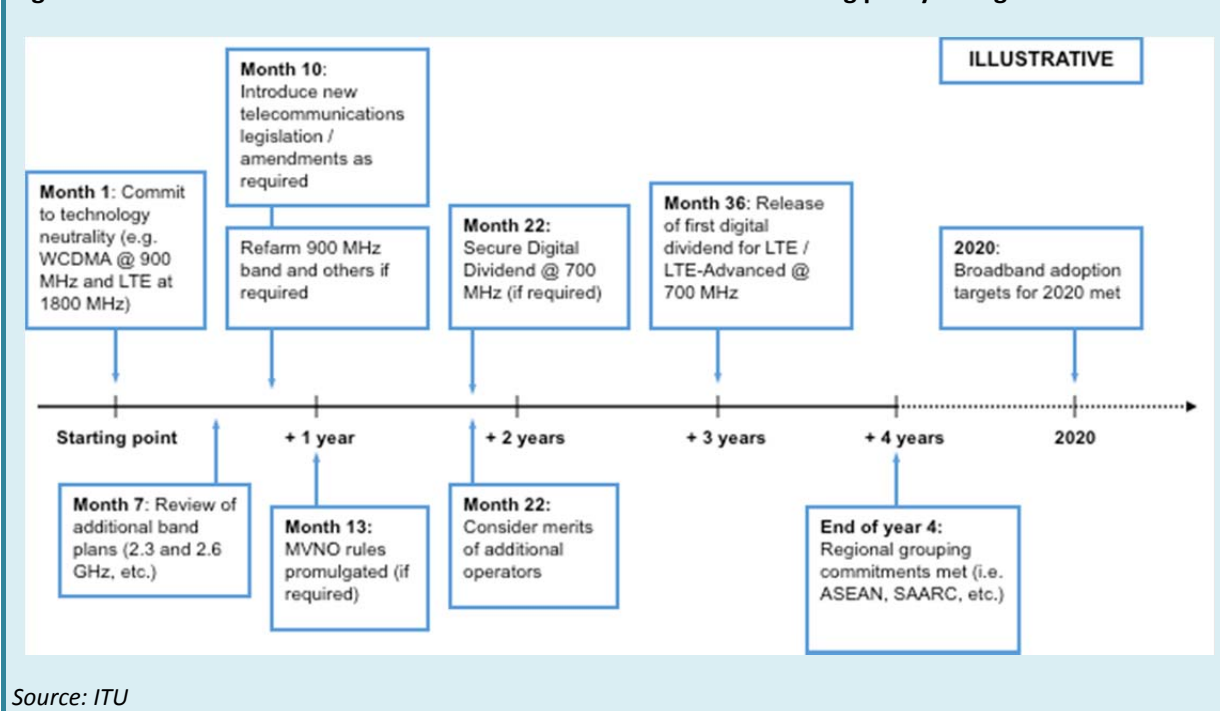
Source: ITU

Appendix A: Draft telecommunication service licence

1. Grant of licence

In exercise of the powers conferred by Sections X of the Act, the Regulator hereby grants a non-exclusive licence ("this Licence") to [Company X], a company duly incorporated in X whose registered office is situated at [ADDRESS] (hereinafter referred to as "the Licensee") to operate and provide the Licensed Services within national boundaries.

2. Interpretation

2.1   The terms in this Licence shall have the same meaning as prescribed in the Act, unless the contrary intention appears.

2.2   In this Licence, unless the contrary intention appears:

"Billing Process" means the Billing System and Metering System collectively.

"Billing System" means the totality of the equipment, data, procedures and activities which the Licensee uses to determine the charges to be made for usage of the Licensed Services.

"Competition Regulations" means the regulations pertaining to competition matters prescribed or to be prescribed by the Regulator pursuant to the Act.

"Customer" means a person having a contractual relationship with the Licensee for the provision of the Licensed Services.

"Exempted Operator" means a person who has been granted an exemption from licensing pursuant to Section 24A of the Act.

"Interconnection Agreement" means an agreement entered into between the Licensee and:

(a)   a Licensed Operator; and/or

(b)   an Exempted Operator;

pursuant to Section X of the Act.

"Interconnection Regulations" means the regulations pertaining to interconnection matters prescribed or to be prescribed by the Regulator pursuant to the Act.

"Licensed Operator" means a person who has been granted a licence under Sections XX of the Act to provide or operate a national telecommunications service

"Licensed Services" means the telecommunication services which are more particularly described in Schedule A

"Metering System" means the equipment, data, procedures and activities which the Licensee uses to determine the extent of any Licensed Services which it has provided.

"Radio Frequency Spectrum Licence" means the licence granted to the Licensee to use the radio frequency spectrum for the purposes of operating and providing the Licensed Services.

2.2   Except where the contrary intention is expressed or arises by necessary implication in this Licence words referring to the masculine gender shall include the feminine gender and references to the singular include the plural and vice versa.

2.3   The interpretation of this Licence shall not be affected by any headings.

2.4   This Licence is subject to the provisions of the Act and is governed by national law.

2.5   In this Licence, all references to an act (whether in conjunction with the title to that act or otherwise) or to the Act mean the legislation as in force from time to time or the legislation in place in whole or in part thereof as well as any subsidiary legislation, regulation, direction, codes

of practice or any provisions thereof in force from time to time and those enacted or made (as the case may be) in place or substitution or modification in whole or in part of any other ordinance, the Act, subsidiary legislation, regulation, direction and codes of practice or provision thereof.

2.6   At any time, any terms or conditions of this Licence which are or declared by any court or tribunal of competent jurisdiction to be illegal, invalid or unenforceable in any respect under the applicable law shall be severed from this Licence to the maximum extent permissible by the applicable law without in any manner affecting the legality, validity or enforceability of the remaining terms and conditions of this Licence, all of which shall continue in full force and effect.

2.7   In the event of any conflict or inconsistency between the Schedule and the terms and conditions in another part of this Licence, the latter shall prevail.

3.   Scope of the licence

3.1   The Licensee shall operate and provide national Licensed Services.

3.2   The Licensee shall provide the Licensed Services to every person who requests for provision of such services within national boundaries.

4.   Term of licence

4.1   Subject to Conditions 29, 30 and 32, this Licence shall be valid for a period of 10 years from the grant of this Licence.

4.2   Upon the expiry of the initial term, this Licence may be further renewed for subsequent term of five (5) years or such other period as the Regulator thinks fit and in accordance with Section X of the Act.

5.   Licence fees

5.1   The Licensee shall pay:

(a)   on the grant of this Licence, an approval fee of [   ] or such other amount determined by Regulator under Section X of the Act;

(b)   annually thereafter a renewal fee of [ ] or such other amount determined by the Regulator;

(c)   royalty to the Government of such amount and at such time as specified by the Regulator; and

(d)   annually such amount specified by the Regulator to a universal service fund.

6.   Description of licensed services

6.1   The Licensee shall not operate or provide any telecommunication service not described in Schedule A except with the prior approval of the Regulator.

6.2   In the event that the Licensee wishes to make changes to the Licensed Services, or introduce a telecommunication service, the Licensee shall provide the Regulator with such information as may be required for the Regulator's consideration and obtain the approval of the Regulator prior to making any change to the Licensed Services, or introducing the new telecommunication service.

7.   Licence replaces any other licence

7.1   This Licence replaces any other licence held by the Licensee in respect of the Licensed Services.

8.   Licence is not transferable

8.1   The issue of this Licence is personal to the Licensee and this Licence shall not be assigned, transferred, sublet or otherwise disposed to any other party except in accordance with Section X of the Act.

9.   Submission of tariff

9.1   Prior to providing the Licensed Services, the Licensee shall submit to the Regulator a tariff specifying the maximum and minimum charges for such Licensed Services for the Regulator's consideration and approval.

9.2   The tariff submitted pursuant to Condition 10.1:

(a)   shall be in a form approved by the Regulator;

(b)   shall be precise and sufficiently detailed to enable the Regulator to work out the nature and the amount of charges payable for the supply of the Licensed Services; and

(c)   must:

(i)   state the period for which it shall apply;

(ii)   state the services and a description of the services that the Licensee proposes to offer during the term;

(iii)   set out the details of the nature and amount of charges payable for the services, indicating where relevant, the services that are provided free of charge; and

(iv)   where the charges vary in their nature or amount or both in relation to the services, the reasons why and how the charges vary.

10.   Publication of charges, quality of service standards and conditions of licensed services

10.1   The Licensee shall publish information about the Licensed Services and provides information covering inter alia details of its tariffs and fees, quality of service standards, provision of fault repair and other terms and conditions on which the Licensed Services are provided by:

(a)   sending a copy of the relevant details to the Regulator;

(b)   making them available for inspection at its major places of business during normal business hours; and

(c)   sending the appropriate parts thereof to any person who makes a request for it.

10.2   The Licensee shall provide a help line service to its Customers whereby any Customer may receive information about any aspect of the Licensed Services.

10.3   The Licensee shall publish, at such intervals and in such a manner as the Regulator may specify, inter alia the description, the quality of service standards, the charges and terms and conditions on which the Licensed Services are provided.

11.   Billing

11.1   The Licensee shall provide its Customers with periodic, accurate and timely invoices which reflect inter alia the itemised charges for each Licensed Service provided, the terms and conditions on which the Licensed Services is provided and the due date for payment.

11.2   The Licensee shall maintain in operation such a Billing Process in order to comply with Condition 11.1. For the purpose of clarification, the Licensee may at its discretion outsource the billing

processes but shall at all times be responsible for meeting its billing obligations under this Licence.

12.   Customer service standards, consumer protection and handling of complaints

12.1   The Licensee shall develop, publish and enforce guidelines for use by its personnel when handling enquiries and complains from or on behalf of any person to whom it supplies Licensed Services.

12.2   The guidelines must address inter alia the following areas:

(a)   procedures for handing of complaints;

(b)   procedures adopted by the Licensee to ensure accuracy of a customer's account; and

(c)   availability to customers of quality of service information relating to the Licensed Services.

12.3   The Licensee shall receive and consider any comment and complaint from or on behalf of any person who believes himself to have been treated unjustly or unfairly in relation to the Licensed Services.

12.4   The Licensee shall keep a complete record in writing of all comments and complaints received by it and submit it to the Regulator on demand. In addition, the Licensee shall keep a complete record in writing of information relating to invoices, charges, directories and inquiries received by it. The records shall be retained by the Licensee for not less than six (6) months.

13.   Universal service obligation

13.1   The Licensee shall comply with the universal service obligations and contribute to the Universal Access Fund in accordance with the Act.

14.   Access and interconnection

14.1   Unless otherwise exempted by the Regulator, the Licensee shall where reasonably practicable, provide access to its Licensed Services, as the case may be, to other Licensed Operators and/or Exempted Operators on reasonable terms and conditions.

14.2   Pursuant to Condition 14.1, the Licensee shall enter into interconnection arrangements with other Licensed Operators and/or Exempted Operators on mutually agreeable terms and conditions, and in accordance with Section X of the Act.

14.3   The Licensee shall comply with Section X of the Act in relation to any interconnection dispute.

15.   Operation of radio apparatus

The Licensee shall apply for and obtain all necessary rights and licences under the Radio Act or such other subsidiary legislations for the operation of any radio apparatus and shall abide by the conditions imposed thereunder, including the payment of licence fees.

16.   Use of radio frequencies

16.1   Subject to the Radio Act and this Condition, the Licensee shall use the radio frequencies allocated and granted to the Licensee pursuant to a Radio Frequency Spectrum Licence to enable the operation and provisioning of the Licensed Services, and shall at its discretion, use any part of the radio frequencies allocated to it for the purposes of managing interferences.

16.2   The Licensee shall take all necessary steps to ensure that the radio-communication apparatus is safe and does not cause harmful interference to other existing radio apparatus in the same or other areas or radio frequency bands.

17.   Technical standards

17.1   The Licensee shall comply with the technical standards where such technical standards relate to the Licensed Services.

18.   Compliance with numbering plans

18.1   The Licensee shall comply with the Regulator's numbering plan on the usage, allocation and assignment of numbers in relation to the Licensed Services.

18.2   The Regulator may alter and/or relocate and reassign any mobile numbers given to the Licensee at any time provided that prior written notice has been given.

18.3   The Licensee may at its discretion, allocate addresses and numbers to its customers within its allocated addressing blocks.

19.   Restriction against anti-competitive conduct and arrangements

19.1   The Licensee shall not engage in any conduct or enter into any agreement or arrangement which shall in any way prevent or restrict competition in relation to the provision of the Licensed Services by the Licensee.

19.2   The Licensee shall comply with the Competition Regulations issued by the Regulator.

20.   Restriction on discrimination

20.1   The Licensee shall not show undue preference towards, or exercise undue discrimination against any person or class of persons in relation to the provisioning of the Licensed Service or the charges for such Licensed Service.

21.   Ownership, shareholding, management and merger arrangements

21.1   The Licensee shall obtain the approval of the Regulator and observe and comply with the regulations promulgated by the Regulator relating to:

(a)   any change in the ownership, shareholding or management of the Licensee at which has the effect of transferring the control over the activities under this Licence; or

(b)   any merger of the Licensee with any other Licensed Operator and/or Exempted Operator.

22.   Direction by the Regulator

22.1   The Licensee shall comply with any directions issued by the Regulator in exercise of its powers, functions or duties under the Act or in this Licence.

23.   National emergency

23.1   Where required by the Regulator, the Licensee shall participate in any emergency, disaster or security activities in collaboration with other Licensed Operators and relevant agencies, organisations and Government departments. Any such emergency shall only extend for such period as may be reasonable given the circumstances.

24. Dispute resolution

24.1 In the event that the Licensee fails to reach an agreement with other Licensed Operators and/or Exempted Operators on matters relating to the Act or this Licence, the Licensee may refer the matter in writing to the Regulator to resolve the dispute.

24.2 The decision of the Regulator shall be binding on the Licensee and the other Licensed Operators and/or Exempted Operators who are parties to the dispute.

25. Accounts

25.1 The Licensee shall mail the Regulator full and accurate books and accounting records reflecting all financial matters in accordance with sound and acceptable accounting practices.

25.2 The Licensee shall so far as it is reasonably practicable, prepare and deliver to the Regulator separate accounting records as may be required by the Regulator from time to time. The Licensee shall comply with all directions issued by the Regulator in relation to accounting separation.

26. Provision of information to the regulator

26.1 The Licensee shall deliver at such time and in such manner as may be specified by the Regulator, all such documents, accounts, estimates, annual return or other information within its knowledge, custody or control as the Regulator may require in connection with the performance of its functions and duties under the Act.

27. Customer privacy and confidentiality

27.1 The Licensee and the Regulator shall keep confidential all information of the Licensee:

(a) which is disclosed, communicated or delivered; or

(b) comes to its knowledge or into its possession in connection with this Licence;

and must:

(1) not use, comply, reproduce and/or reduce to writing or communicate or otherwise make available such information except for the purposes of this Licence or as required by the Act; and

(2) not disclose or communicate, caused to be disclosed or communicated or otherwise make available such information to third person other than its directors, officers, employees and/or professional advisers to whom disclosure is necessary for the purposes of this Licence; and

(3) apply thereto no lesser security measures and degree of care than those which applies to the Regulator's own confidential or proprietary information and which the Regulator warrants as providing adequate protection for such information from unauthorised access, copying or use.

28. Safety

28.1 The Licensee shall, in respect of all installations, equipment and apparatus possessed, operated or used in relation to the provision of the Licensed Services under this Licence, take all proper and adequate safety measures for the safeguarding of life or property, including safeguarding against exposure to any electrical or radiation hazard emanating from the installations, equipment or apparatus so used.

28.2 The Licensee shall comply with any direction of the Regulator in respect of any safety matter.

29.   Variation or amendment to the licence

29.1   The Regulator may vary or amend any of the conditions of this Licence in accordance with Section X of the Act.

30.   Suspension or cancellation of the licence

30.1   The Regulator may suspend or cancel this Licence in accordance with Section X of the Act.

31.   Breach of licence conditions

31.1   Where the Licensee breaches any condition of this Licence, the Licensee shall be guilty of an offence and shall be convicted in accordance with Section X of the Act.

32.   Surrender of the licence

32.1   In the event that the Licensee wishes to terminate this Licence or cease to operate or provide the Licensed Services, the Licensee shall notify the Regulator in writing at least three (3) months in advance.

33.   Rights upon suspension, cancellation or termination

33.1   Suspension, cancellation or termination of this Licence, in whole or in part, is without prejudice to any rights, liabilities or obligations which may accrue to the Licensee or Regulator under this Licence or any written law at the date of the suspension, cancellation or termination, including a right of indemnity.

34.   Governing law

34.1   This Licence shall be governed and construed in accordance with national law.

35.   Compliance with the law and international conventions

35.1   The Licensee shall, unless otherwise directed by the Regulator, at all times observe and perform the relevant requirements of the Act and Convention of the International Telecommunication Union including all regulations annexed thereto or made thereunder, and any other telecommunication agreements which may from time to time be acceded to by or on behalf of, or applied to, the nation.

36.   Regulator's powers

36.1   In exercising its powers granted in terms of the Act, and this Licence, the Regulator shall:

(a)   act reasonably having regard to all surrounding circumstances;

(b)   prior to exercising its power, afford the Licensee every reasonable opportunity to be heard and make representations to the Regulator in respect of all relevant issues; and

(c)   at the request of the Licensee, furnish written reasons for any decision it makes in relation to this Licence.

Schedule A

Licensed services

The Licensee is licensed to operate and provide any Telecommunication Services within national boundaries including but not limited to:

(1)

(2)

(3)

Appendix B: Outline of recommended process to introduce sector competition and attract new investment

B.1   Overview

As indicated in the main body of the Guidelines, to create viable competition and an optimal environment in order to address the issues of low teledensity and the digital divide, the introduction of sector competition is recommended. This is particularly important for developing countries where market competition is lacking and where the market is dominated by one or very few operators. To ensure a competitive market with lower consumer tariffs governments should consider the introduction of new mobile operators to be licensed in order to compete against existing operators.

The key challenge is to design a process that will see:

(i)   The viable entry of new licensees into the market that will be able to compete with existing operators for the provision of both mobile voice and wireless broadband services.

(ii)   The securing of significant one off and on-going fees for the Government. Part of the monies raised could be used to provide existing Government operators with a significant capital injection so that they can quickly grow in competition with the new entrants.

To address these twin challenges, a two-stage process is preferred with a first stage pre-qualification of short listed bidders to be followed by an auction. Following a successful licensing process, the market will also be suitably primed for the allocation of additional spectrum, and/or the possible entry of a second round of new providers. This could potentially be achieved say, after 2015 or 2016.

B.2   Pre-qualification phase

B.2.1   Overview

The process that could be followed for the introduction of additional providers of mobile/wireless services is as detailed below. The procedures may be divided into a number of key steps:

(i)   preliminary steps;

(ii)   request for proposal (RFP) process;

(iii)   establishing an evaluation team;

(iv)   budget planning / consulting;

(v)   defining the investment opportunity;

(vi)   inviting applications from prospective applicants;

(vii)   preparing an applicant information package;

(viii)   developing an evaluation and ranking criteria; and

(ix)   receiving and considering applications.

B.2.2   Preliminary steps

Valuable spectrum is currently under-utilised in many developing countries. In some cases governments will need to commit to an initial reallocation of GSM 900 MHz band spectrum.

A reassignment (i.e. refarming) of certain spectrum may also necessary to enable the entry of new competitors into a mobile market.

For example, suppose one operator holds 2 x 25 MHz – the entire GSM 900 band - of paired 900 MHz band frequency. In order to secure an acceptable competitive environment, the government and regulator should commit to allowing one or more operators to secure a footing in the market. If there are

two new operators this will necessitate two separate 2 x 10 MHz allocations to the prospective new entrants. Following the conclusion of the pre-qualification phase, the new allocation would see two operators with 2 x 10 of 900 MHz band spectrum, while the existing operator would retain 2 x 15 MHz of 900 MHz spectrum including any guard bands (approximately 200 KHz between operators) – a total of 2 x 35 MHz of 900 MHz band. Similar processes could apply in relation to 700, 1800 and 2100 MHz spectrum as required.

This would be done as early as possible to allow time to transition to the new arrangements.

The regulator could consider offering potential applicants a period of exclusivity, two years for example, on additional telecommunications licences. This will help ensure that licensees assume the capital expenditure and risk that is necessary to generate effective competition and infrastructure that is capable of meeting the country's communications needs.

B.2.3   Request for proposal (RFP) process

A draft call for proposals from suitably qualified applicants for a cellular wireless licence is provided in Box B.1.

B.2.4   Project evaluation team

To ensure their efficient execution, the overall licensing procedure must be planned and undertaken according to a set timetable and with tasks assigned to an appropriate working group comprising representatives from the Ministry, the government, existing operators and other arms of government as may be required or appropriate. Such a working group may be called the Licence Evaluation Committee ("LEC") and would function under the overall supervision of the relevant Minister.

The LEC must represent the relevant arms of government and have, either within the individual team members or in available support staff, the necessary expertise to make an effective evaluation of the applications. Importantly, the LEC must have a leader and be able to make those decisions that are necessary to perform the evaluation.

Under the direction of the Ministry and regulator, members would work to a timetable setting out key milestones. The leader would be accountable for managing all aspects of the task and ensuring that project outcomes are delivered on time.

The LEC would be expected to manage the licensing exercise as a specific project. That is, the process requires dedicated staff empowered to undertake and complete the project within the parameters of:

- specific objectives and outcomes;
- a set timetable; and
- specific human and financial resources.

B.2.5   Budgetary planning / consulting

The regulator will need to undertake a budgetary planning process and advise the Ministry of the anticipated expenditures that the pre-qualification phase will entail. The services of an external consultant may be required to assist the regulator with the planning and allocation of tasks.

B.2.6   Defining the investment opportunity

This step involves documenting the details of the investment opportunity. This involves determining the precise parameters of the investment that is being offered to investors.

Box B.1: Preliminary draft call for applicants

DRAFT CALL FOR APPLICANTS FOR CELLULAR WIRELESS LICENCE (PRE-QUALIFICATION PHASE)

The Government of [country name] is committed to the liberalisation, growth and development of its telecommunications sector. In particular, the government wishes to introduce two new independent operators to provide nationwide GSM mobile and wireless broadband cellular services. The government will seek applications from interested parties to take up the investment. There will be a pre-qualification phase including eligibility criteria for successful applicants, set out below, with allocation then taking place via auction.

The key parameters of the investment opportunity are as follows:

New Operators

The government will authorise two new operators to provide mobile cellular services. The government will not issue any further authorisation for the provision of mobile cellular services for at least 2 years from their licensing.

Nationwide Coverage

Licensees will be authorised to provide services throughout the territory of [country name]. The areas covered and the rollout timetable should be proposed by applicants. Approval of local government for the installation of network infrastructure will be required.

Wireless Technology

Each of the new operators will be provided with 2 x 10 MHz of 900 MHz spectrum, 2 x 10 MHz of 1800 MHz and the right to acquire 2 x 10 MHz of 2100 MHz radio frequency spectrum. The rights offered will be technology neutral permitting the successful applicant to deploy W-CDMA at 900 MHz and/or LTE at 1800 MHz.

Eligible Applicants

Applicants must be companies registered in [country name] or joint venture companies. Foreign investment will be permitted up to [X] per cent of the share capital of the applicant.

Services

The new operators will be required to provide interconnection with all other operators. It may provide its own international and domestic transmission links or lease capacity from the existing operator. The applicant will be expected to undertake commercial negotiation with these operators concerning interconnection.

Performance Bond

The new operators will be required to post a performance bond equal to 10 per cent of the expected capital expenditure incurred in the first two years after the licence is granted.

B.2.7   Encouraging applications from prospective applicants

The publicity associated with opening up a country's telecommunications market for new entrants and the resulting financial opportunities will be significant factors in driving applications from prospective applicants.

This part also requires matching the requirements of investors with the characteristics of the investment opportunity. In turn this may mean structuring the investment opportunity in such a way to ensure that the needs or requirements of key potential applicants are provided. For example, tax concessions might

be made available to the successful applicant. Prospective applicants need to be assured of regulatory certainty. Efforts need to be made to provide both English language and native language documentation, with the applications to be made in English (where the country is not primarily an English-speaking country).

In order to create a favourable investment climate, the government should consider relaxing foreign investment laws as it is highly likely that the interested parties will not be local. This may take the form of allowing say 90 per cent ownership with a graduating sell-off requirement to occur over a defined period of time.

B.2.8   Preparing applicant information package

This step involves the preparation of an applicant information package. This package provides all the basic information that a potential investor requires to make an assessment of whether to submit an application and how an application should be made.

Relevant information to be provided in an applicant information package will include:

- the government telecommunications policy statement and its commitments relevant to the investment opportunity, e.g., a commitment to not licence any additional cellular mobile operators for say two to three years;
- the relevant telecommunications law and regulations pursuant to the those laws which concern the investment opportunity (assuming the passage of the new law);
- basic facts about the country and the investment climate – population, GNP per capita, population density and age profile population, climatic conditions, teledensity, industry structure, regulatory structure, etc.;
- sample licence that would be awarded;
- the form of application, i.e., the information to be included in an application;
- evaluation criteria that will be used to assess applications;
- timetable to be followed in the application evaluation process;
- instructions on how applications are to be lodged, i.e., date, place, payment of application fees etc.; and
- the process for dealing with queries from applicants.

It should be recognised that the process of licence application evaluation is necessarily a subjective task requiring judgements to be made. The degree of subjectivity can, however, be reduced through a carefully managed process which requires licence applications to be structured and presented in a common format to facilitate ease of comparison.

B.2.9   Developing application evaluation and ranking criteria

Evaluating applications may take the form of a two-step process. Step 1, a shortlisting of criteria, involves a checklist to ensure that only complete and genuine applications proceed to the next stage. This shortlisting criteria for a telecommunications licence opportunity may be set out in four parts:

1. Financial Capability
2. Technical Capability
3. Management and Technical Expertise
4. Corporate Governance

A suggested ranking criteria is provided in Table B.1. The framework is applied by evaluating each application and awarding highest point to the application that best fulfils the criteria.

Table B.1: Ranking criteria

Ranking Criteria	Relative Weighting	Numeric Weighting
Technical Quality	High	**20%**
• Network coverage		
• Grade of service		
• Network interconnection		
• Network design and configuration		
Financial Capability	High	**20%**
• Financial soundness		
• Extent of financial commitment		
• Access to financial resources		
• Business plan		
Customer Service and Support	Medium	**15%**
• Service range		
• Customer segmentation		
• Retail and service outlets		
Implementation Schedule	Medium	**15%**
• Network roll out plan		
• Ability to acquire and manage telecommunications sites and facilities		
• Ability to manage major infrastructure projects		
Management and Technical Expertise	Medium	**15%**
• Experience in operating public telecommunications services		
• Knowledge of the country's business environment		
• Management support		
• Technical support and personnel		
Industry Development	Medium	**10%**
• Local employment opportunities		
• Local supply		
• Staff training and development		
Corporate Governance	Low	**5%**
• Corporate structure		
• Shareholders' agreements		

B.3 Auction processes

B.3.1 Overview

Assuming there are multiple applicants who pre-qualify, the regulator will need to select the most appropriate means of allocating the licences to best placed bidders. While a 'beauty contest' could be utilised, the optimal approach that is consistent with global best practice is to allocate the licences by auction. It should be noted that the same price based methods may also be employed for the subsequent allocations of spectrum solely – including the 700 MHz spectrum and any remaining 1800 and 2100 MHz spectrum.

B.3.2 Auctions

In an auction, licences are awarded by bidding between competing applicants either for a licence with spectrum or spectrum separately. Auctions award licences to those who value them most highly while simultaneously generating revenues for the government.

However, as is the case with an unrestricted spectrum market, auctions may raise competitive concerns if not combined with an active competition policy and limits on how much spectrum an entity may purchase.

Market forces do not ensure economic efficiency or maximize consumer welfare in markets that are not competitive because a dominant service provider or group of providers have market power.

While auctions are the assignment mechanism best suited to providing an initial economically efficient distribution of the spectrum resource, they will not ensure that spectrum continues to be used in an economically efficient manner in the future.

As with other resources, economists recommend that spectrum users be allowed to transfer their spectrum rights (whether assigned by auction or some other assignment mechanism) and that spectrum users have a high degree of flexibility in the choice of the consumer services that they provide with their spectrum.

Auctions have the advantage of awarding licences to those who value them most highly, while simultaneously generating revenues. When auctions are used to assign licences within a given allocation structure, licences are awarded to those who value them the most only within the confines of the allocation structure. Other expected benefits associated with auctions may be fairness, transparency, objectiveness, and the speed with which licenses can be awarded. Auctions can reduce the opportunities for favouritism and corruption in the competition for spectrum, promote investment, and promote technological advancement.

However, in order to promote competition, it may be necessary to impose additional safeguards, for auctioned services. For example, in some situations some or all of the potential bidders may be dominant service providers who are endeavouring to strengthen their monopoly positions. Restrictions on eligibility to participate in an auction or limits on the amount of spectrum that any entity may win can alleviate this problem, although this may limit the number of participants.

The types of auctions are summarised in Box B.2.

Box B.2: Types of auctions

There is a surprisingly wide array of choices of forms an auction may take. The choice of auction mode will vary with the nature of licenses made available, the number and nature of firms with an interest in theirs and the regulator's or government's objectives:

- English auctions or simultaneous ascending auction (SAA) – where blocks of spectrum are awarded to the highest bidder remaining who has exceeded the opening price set by the regulator;
- Dutch auctions – where the ultimate price paid is determine after succeeding descending rounds from an initial high price set by the regulator;
- First-price sealed-bid auctions – where participants submit their bid without any information on prices and the highest bidders wins;
- Second-price sealed-bid auctions – similar to the previous method except the second highest price is selected;
- Simultaneous ascending auction (SAA) sealed-bid hybrid Auctions – where SAA is used in the first several rounds and first-price sealed-bid is used in the final round.
- Simultaneous multi-round ascending auctions: This format is used when there are many spectrum lots to be allocated together across a range of different geographic areas and there are different band segments.

All lots are simultaneously on offer over multiple rounds of bidding. Bidders may bid on any lot or combination of lots in each bidding round. At the end of each round high bids are disclosed and all bidders can bid again in the next round to become the high bidder. In general, after a round with no more bids, the bidders holding the high bids in the previous round win the lots.

B.4   Subsequent allocations of spectrum

Following the introduction of competition into a country's mobile service market, the regulator may decide to release more high-demand spectrum on a technology-neutral basis following the expiry of any exclusivity period. Consequently, the government could expect to earn more revenue from the sale of spectrum due to increased demand and revenues that are being generated by the sector.

If a country retains unallocated 700 MHz band, for instance due to the non-existence of UHF television, then it is in a stronger position. This lower-band spectrum is valuable due to its capacity, geographical coverage and international harmonisation efforts; it is highly suitable for mobile broadband. It is expected that there will be sufficient capacity so as to not warrant the allocation of 2.6 GHz spectrum at least until much later.

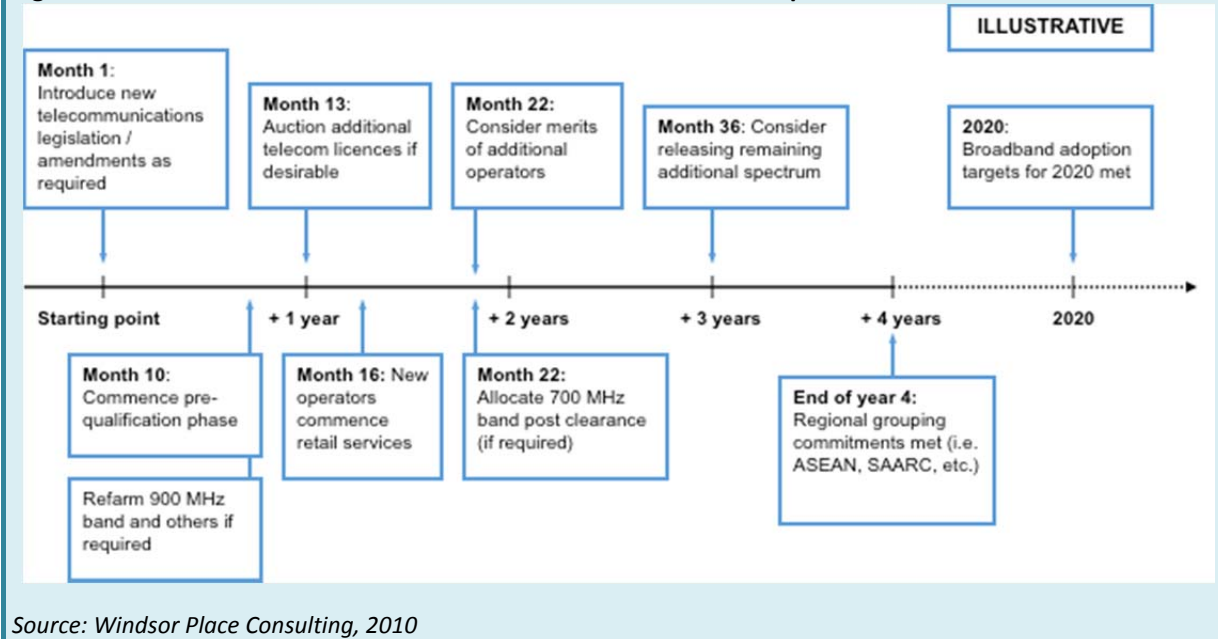## B.5   Suggested licensing process timeline

Suggested licensing process timeline for government where it has been determined that there is insufficient effective competition are detailed in Table B.2 and Figure B.1.

These milestones and actions are based on Asia Pacific regional requirements, as well as various regional and national plans, and incorporate the Broadband Commission's targets. The introduction of sector competition by the licensing of additional cellular mobile operators is proposed to take place at the start of the second year of implementation, after which the regulator will assess the market and consider the merits of additional operators. The release of additional spectrum, especially in the 700 MHz band, is timed to take place at the end of the second year but this would need to be assessed on an individual market basis.

Table B.2: Key recommended action items where effective competition is deemed insufficient

Date	Action
Month 1	• Introduce new telecommunications legislation / amendments as required
Month 10	• Commence pre-qualification phase • Refarm 900 MHz band and others if required
Month 13	• Auction additional telecom licences if desirable
Month 16	• New operators commence retail services
Month 22	• Consider merits of additional operators • Allocate 700 MHz band post clearance (if required)
Month 36	• Consider releasing remaining additional spectrum
End of year 4	• Regional grouping commitments met (i.e. ASEAN, SAARC, etc.)
2020	• Broadband adoption targets for 2020 met

Figure B.1: Recommended timeline for action where effective competition Is deemed insufficient

ILLUSTRATIVE

Month 1: Introduce new telecommunications legislation / amendments as required

Month 13: Auction additional telecom licences if desirable

Month 22: Consider merits of additional operators

Month 36: Consider releasing remaining additional spectrum

2020: Broadband adoption targets for 2020 met

Starting point   + 1 year   + 2 years   + 3 years   + 4 years   2020

Month 10: Commence pre-qualification phase

Month 16: New operators commence retail services

Month 22: Allocate 700 MHz band post clearance (if required)

End of year 4: Regional grouping commitments met (i.e. ASEAN, SAARC, etc.)

Refarm 900 MHz band and others if required

Source: Windsor Place Consulting, 2010

Appendix C: Spectrum caps in key global developed and emerging markets (as at December 2011)

Country	Spectrum Caps?	Details
Australia	Yes (for 700 MHz and 2.5 GHz)	The Australian government has set a limit of 2 x 20 MHz of spectrum in the 700 MHz spectrum band and of 2 x 40 MHz in the 2.5 GHz spectrum band. These are the maximum amounts of spectrum that any one market player can purchase and are designed to increase competition in the sector. They effectively ensure a minimum of three (3) service providers with access to the spectrum as well as allowing for a potential newcomer to the market
Belgium	Yes (for 2.6 GHz)	Belgium adopted a different approach to freeing spectrum in the 2.6 GHz band for wireless broadband services than its European counterparts. The regulator, BIPT, opted to issue for blocks of 2 x 15 MHz with 2 x 5 MHz blocks at the end of the paired bands. BIPT has imposed a paired spectrum cap of 2 x 20 MHz, but the cap does not extend to the unpaired spectrum.
Canada	Being re-considered	In 2010, the regulator, Industry Canada, released two Consultation Papers on the reallocation of the 700 MHz and 2.6 GHz bands. The 700 MHz paper raised the possibility of introducing spectrum caps to prevent 'excessive concentration' (i.e. hoarding of spectrum. The regulator recognised that 'setting the right cap is essential.' Three options were canvassed: (a) spectrum to be auctioned in individual bands (700 MHz separately from 2500 MHz); (b) a combination of spectrum to be auctioned in both bands (700 MHz and 2500 MHz); and (c) a combination of spectrum to be auctioned as well as existing spectrum holdings in all or a subset of bands available for commercial mobile systems (Cellular, PCS, AWS, BRS), e.g. spectrum holdings below 1 GHz. In their responses, larger operators were largely opposed to the imposition of spectrum caps. Bell Mobility submitted that, *inter alia*, spectrum caps were not required given the developed state of Canada's mobile market and the absence of a cap in other mobile broadband bands (they were previously rescinded in 2004).
France	Yes (for 800 MHz and 2.6 GHz)	In May 2011 the French Government auctioned the 800 MHz digital dividend band. Four lots of a total of 30 MHz were allocated for 4G services. Operators were limited to a maximum of 2 x 15 MHz. The move was criticised by some industry analysts because the cap effectively meant that a leading operator was able to corner 50 per cent of the best spectrum in one auction. In September 2011, the 2.6 GHz band was auctioned via sealed bid. The cap in this band was 2 x 30 MHz. The remaining spectrum in the 800 MHz band will be auctioned next year following the end of analogue services. French operators generally supported the spectrum caps. Smaller operators have been wary of FT Orange further increasing their mobile market dominance and believed that caps were the best way of reducing its market share.
Germany	Yes (for 800 MHz)	In 2010-11, the German Government completed the reallocation of digital dividend spectrum. In the 800 MHz band, 2 x 30 MHz of bandwidth was auctioned. A spectrum cap of 2 x 10 MHz was implemented. Caps were not mandated for concurrent auctions in the 1800 MHz and 2.6 GHz bands.

Country	Spectrum Caps?	Details
Hong Kong (China)	Yes (for 2.3, 2.5/2.6 GHz)	The auction of wireless broadband spectrum in Hong Kong has been occurring on a staggered basis. In 2009, 195 MHz of spectrum was auctioned from the 2.3 GHz and 2.5/2.6 GHz bands. The Regulator, OFTA, imposed a spectrum cap of 30 MHz. The cap was imposed because OFTA would not accept the prospect of only having one operator that was capable of operating wireless broadband services. A 30 MHz cap was believed to be sufficient for an operator to provide a territory-wide service of acceptable quality. In March 2011, OFTA, announced the upcoming auction of three residual unpaired 30 MHz blocks in the 2.3 GHz band for wireless broadband services following a number of expressions of interest from operators. A cap of 30 MHz was re-implemented. OFTA announced auctions of the 850 MHz, 900 MHz and 2 GHz bands for wireless broadband would occur in February 2011. There were no spectrum cap requirements in this auction.
Nether-lands	Yes (for 2.6 GHz) being considered for 800 MHz	The Ministry for Economic Affairs opted to impose differential caps on entrants and incumbents during the 2.6 GHz band auctions. Bidders were subject to caps of between 5 – 40 MHz, which was dependent on their spectrum portfolios in other bands (e.g. 900 MHZ, 1800 MHz and 2.1 GHz). The Dutch Parliament directed the implementation of these differential caps with the intention of promoting new market entrants. The Ministry sought advice on this issue of spectrum caps for the 800 MHz band. They are considering at the very least the suitability of spectrum caps (possible 2 x 20 MHz) on sub 1 GHz spectrum. Such a cap was said to be appropriate in circumstances where there was a risk of asymmetric spectrum assignments that would have the effect of threatening competition. The auction will occur in late 2011 – early 2012.
Singapore	Yes (for 2100 MHz)	In 2010, the Regulator, IDA, auctioned 3G spectrum in the 2100 MHz band. The Auction Rules specified that 'no bidder which is a member of the SingTel Group, StarHub Group or M1 Group may bid for or be granted a 3G Spectrum Right (2010) in respect of more than two… lots in this Auction'. Three lots of 2 x 5 MHz were up for auction. An auction for 4G spectrum in the 1800 MHz band for 2 x 5 MHz lots was conducted in March 2011. There were no caps imposed on this spectrum.
South Korea	Yes	The rules of the auction in Q3, 2011 dictated that no mobile network operator could acquire spectrum in more than one band. The results were Korea Telecom (KT) won 10 MHz in the 800 MHz band for KRW 261 billion (USD 245 million), SK Telecom (SKT) won 20 MHz in the 1800 MHz band for KRW 995 billion (USD 933 million) and LG Uplus won 20 MHz in the 2100 MHz band for KRW 445.5 billion (USD 412 million). Basically the two dominant mobile operators were barred from competing for spectrum in the 800 MHz and 1800 MHz band for competitive reasons. It is also possible that in a future digital dividend auction the Korean regulator (KCC) may lay down spectrum cap rules to prevent any operator from acquiring relatively inequitable spectrum holdings.
Spain	Yes (for 800 MHz)	Like most EU nations, Spain has been progressing with the reallocation of spectrum following the move from analogue television services. In June 2010, the government announced that it intended to reallocate the 800, 900 1800 and 2600 MHz band for wireless broadband. The Ministry for Industry, Tourism and Communications (MITYC) held the auction for 4G spectrum in August 2011. The cap for the 800 MHz band was set at 2 x 20 MHz.
Sweden	Yes (for 800 MHz)	Sweden concluded its reallocation of digital dividend spectrum in the 800 MHz band between February and March 2011. Successful bidders were bound by a demanding obligations intended to aid in the achievement of the 'Broadband Strategy for Sweden'. Caps of 2 x 10 MHz were imposed and a total of 2 x 60 MHz was allocated to wireless broadband.

Country	Spectrum Caps?	Details
United Kingdom	Proposed for 800 MHz and 2.6 GHz	Ofcom is finalising its plan for the auction of the digital dividend 800 MHz and the 2.6 GHz bands, following its recent announced delay. In its May 2011 Consultation Paper, Ofcom proposed a cap of 2 x 27.5 MHz for sub-1 GHz spectrum and a total limit of 2 x 105 MHz mobile spectrum. The decision as a plus for Three UK, which had lobbied hard for the imposition of spectrum caps. They argued that January 2011 re-allocation of 2G spectrum was highly advantageous for Vodafone, O2 and Everything Everywhere.
United States	Yes, (until 2003, now screening threshold applies)	Until 2003 the FCC mandated spectrum caps as a means of ensuring effective competition during the developing phase of the mobile market. Operators were capped at 2 x 45 MHz spectrum within a designated geographic area. At the time, total mobile spectrum was 180 MHz. Other limitations on spectrum ownership enforced by the FCC were: • the aggregation of broadband PCS spectrum (40 MHz cap); • cellular / PCS cross ownership – a cap of 10 MHz PCS spectrum for an operator within its service area; and • cellular cross-interest rules on the ownership interest of cellular operators in overlapping geographic areas. Spectrum caps were rescinded in 2003. Auctions since then have seen the FCC follow a 'screening guideline' of 70 MHz (later raised to 95 MHz following the 700 MHz band auction) where an operator may be subject to review if they exceed that threshold. Controversy arose following the 700 MHz wireless broadband spectrum auctions in late 2010. Smaller rural operators claimed that incumbents like AT&T were positioned to exercise their dominant market power and effectively exclude them from the mobile market. In January 2011, the Rural Telecommunications Group sought an injunction from AT&T from acquiring 700 MHz assets from a small Pennsylvanian provider and Qualcomm. They have asked the FCC to limit licensees from controlling more than 110 MHz below the 2.3 GHz band. The result of this action is pending. This issue of wireless competition and control over spectrum was examined as part of the review of the proposed AT&T and T-Mobile merger which ultimately resulted in AT&T declining to proceed with the merger.

Source; Windsor Place Consulting analysis 2011

Appendix D: Summary of regulation of MVNOs in selected country markets

Country	MVNO access and other requirements
Brazil	• In December 2010, the Brazilian National Telecommunications Agency (ANATEL) approved the 'Regulation on the Exploitation of Personal Mobile Services via Virtual Networks' following stakeholder consultation. • The regulatory framework provides a model which allows for MVNOs to operate as 'agents' or virtual network licensees. An agent represents the mobile service provider through the establishment of an agreement ratified by ANATEL. A virtual network licensee falls within the legislation's definition of telecommunications service and, consequently, all applicable rules. The new dichotomy will likely prove beneficial for non-telecommunications service providers because the agent's activity is not defined as a 'telecommunications service' thereby providing scope for non-telcos to enter the market. • The regulation deregulates the activity of agents. A key feature includes the removal of the requirement for agents to have prior qualification with ANATEL.
Denmark	• In 2000, Denmark introduced mandatory wholesale access after determining that two of its mobile network operators (MNOs), TDC and Sonofon possessed significant market power. • This followed regulatory complaints stemming from a 1998 attempt by a Norwegian MNO to negotiate an access agreement with Sonofon that was denied. • While the MNOs remain the central market players, the MVNOs have acquired a combined market share of over 26 per cent. This is notwithstanding that in 2006, the regulations were withdrawn; deemed unnecessary under the revised EC guidelines. Denmark now has no MVNO related regulation after initially facilitating their access.
Hong Kong (China)	• OFTA, the Hong Kong (China) regulator chose to make MVNO access a condition of the awarding of 3G MNO licences. • In 2001, OFTA required 3G licensees to open up 30 per cent of their networks to MVNOs unaffiliated with licensees. This allowed an unlimited number of MVNO licenses to be issued at uniform prices, with no account taken of the scale of the MVNO network. • The objective of non-discriminatory access was supported by requirements that qualifying MVNOs be granted access to the same features that the MNO is able to provide to its customers, such as data rates. Furthermore, MNOs must treat MVNO traffic on a non-discriminatory basis.
India	• The Telecom Regulatory Authority of India (TRAI) published its recommendations on MVNOs in August 2008, in response to a consultation by the Department of Telecommunications. • Driven by the objective of maintaining the exponential growth in telephone connections over the previous few years, TRAI felt that MVNOs had an important role to play in the Indian market. • Based on a survey of other markets, the regulator decided on a light-touch, enabling approach to regulation, where the relationship between MNO and MVNO would be determined by market forces. • The Authority did, however, reserve the right to intervene, without giving further detail as to the appropriate circumstances. • Final approval for MVNO entry was granted by the Indian government in February 2009.
Japan	• In October 2008, Japan's Ministry of Information and Communications (MIC) published its mobile revitalisation plan, requiring mobile operators to reach interconnection agreements with MVNOs and publish their agreed tariffs. • This followed resistance from Japan's three major mobile operators. • At the time of the announcement, 33 companies were engaged in MVNO activity in Japan, with most simply wholesaling mobile data services at a discount. • The two new 2.5-GHz licensees launched in 2009 are obligated to open their networks to MVNOs under the terms of their licenses.

Country	MVNO access and other requirements
Jordan	• In late 2008, Jordan introduced a regulatory framework for the provisioning of MVNO services. While the focus is on commercial arrangements, the Telecommunications Regulatory Commission (TRC) has granted MVNO licensees the right to negotiate "fairly and without unfair discrimination or preferences in order to obtain access to the MNO's underlying network infrastructure and Telecommunications System." • The regulations provide further protection to MVNOs by prohibiting host MNOs from undertaking win-back campaigns for the first six months that the MVNO provides services to customers. • The TRC has issued MVNO licences to Friendi Group and i2.
Korea	• As a condition of issuing WiBro licences to three operators in 2005, the Ministry of Information and Communications required that the licensees provide 30 per cent of their network capacity to MVNOs either three years after the launch of their WiBro services or once the total number of WiBro subscribers reached 5 million. Until then, no MVNOs would be permitted to operate in South Korea. This never came in to effect. • In March 2010, Korea's National Assembly passed a bill paving the way for MVNO entry in an attempt to reduce call charges. It came into effect in September 2010. • On account of its dominance, SK Telecom will be required to provide resale services.
Israel	• The government announced its intention to permit the entry of MVNOs in early 2009. • Regulations were introduced making it harder for affiliates of existing licensees to enter the mobile services market. These changes precluded NetVision from acquiring an MVNO license because it was a sister company of Cellcom, an existing mobile operator.
Macedonia	• Approval for the provisioning of MVNO services was first suggested by the Macedonia Government in September 2010. In a statement issued by the Minister wrote that MVNO services were to be facilitated by a reduction in interconnection fees. • Two months later, WTI Macedonia was confirmed as the country's first MVNO.
Mexico	• In October 2009, Mexico's Federal Telecommunications Commission (Cofetel) indicated it was currently developing new regulation to boost the entrance of MVNOs on the local market. According to Cofetel commissioner Jose Luis Peralta, the rules seek to simplify the MVNO authorization process and address issues such as number portability and customer service. • The announcement appears to have been inspired by the fact that no MVNOs have entered the Mexican market, despite the fact that MVNOs are provided for under the existing telecommunications rules.
Norway	• Dominant operator Telenor is required by the Norwegian Post and Telecommunications Authority to provide MVNOs with access.
Pakistan	• The provisioning of MVNO services was first addressed by the Pakistan Telecommunications Authority (PTA) in 2004. • In 2007, the regulator published a framework addressing the rights and responsibilities of MVNOs to be addressed in any commercial agreement. • Commercial agreements between MNOs and MVNOs must be submitted to the PTA. Once approved, the MVNO has 30 days to submit a licence application, along with a USD 5 million application fee. • Draft regulations were released in 2009. These regulations specify the conditions for licence issue and procedure to be followed by applicants.

Country	MVNO access and other requirements
Singapore	• In 2001, the Infocomm Development Authority (IDA) issued a Decision paper on the regulatory approach to 3G MVNOs. • The paper emphasised the regulator's decision process in balancing the desirability of MVNO entry against the potential distortion of commercial decision making that would result from regulatory intervention. • Thus, the IDA took the decision to intervene only in the case of unduly restrictive or anti-competitive practices as defined in the Telecom Competition Code.
Saudi Arabia	• In November 2011, the Communications and Information Technology Minister, Muhammad Jameel Mulla, announced that the government had no plans to licence additional mobile networks in the country but will permit the launch of MVNO based services. • Three MVNO licences were granted and intended to take effect from 2012. This was interpreted as a sign of the government believing that focus should be turned away from infrastructure development and towards price and service competition. • Article 11 of the Telecom Act Bylaws provides the Minister with wide-ranging authority to grant mobile service licenses.
Spain	• In January 2006, the European Commission endorsed the Spanish regulator, 'Comisión del Mercado de las telecomunicaciones'' (CMT) plan to force Spain's three incumbent MNOs, Telefónica, Vodafone and Amena to grant access to their networks at 'reasonable prices'. • CMT's justification for the intervention was the 'common interest' of the MNOs to prevent MVNOs from entering into the market and maintain their high profits. Retail mobile prices are high in Spain, and the EC accepted CMT's submission that the lack of competition in the markets for access and call origination is a likely cause. • The regulations required incumbent MNOs to offer wholesale access to technologies integral to the interoperability of services, devise a means of sharing the use of installations, offer services necessary for interoperability of extreme services with those offered to users, give access to operating support systems and other, similar information systems and enable network interconnection. CMT also set a two month time limit for negotiations between each of the three MNOs and potential MVNOs.
Thailand	• The Thailand regulator, the National Telecommunications Commission (NTC), announced plans to issue three 3G licences in September. The licences, in the 2100 MHz band will feature 15 MHz of spectrum and be valid for 15 years. • While the NTC board has approved the licence conditions, they are not yet finalised, and will be subject to a public hearing on June 25. • A key licence term will require holders to allocate 40 per cent of their network capacity for leasing to MVNOs. An MVNO will be able to lease network capacity from just 1 licence holder at a time. • Currently there is only one 3G operator in Thailand, State-owned TOT, which happens to be operating under the MVNO framework. • However, the passage of the Frequency Allocation Law in 2010, threw existing practice into doubt. Section 46(2) of the law requires NBTC licence holders to use their spectrum to operate only their own business and cannot let others user their spectra to provide services on their behalf. • The NTC reportedly stated that they now believe that the power to grant MVNO licences has been revoked following the release of this policy.
Viet Nam	• The Viet Nam Ministry of Information and Communications has licensed a number of MVNO licensees to utilise the infrastructure of the existing 3G operators. The first MVNO licence was issued in April 2009, with subsequent licences being issued in September 2009.

Source: Windsor Place Consulting analysis of industry sources, 2012

Appendix E: Addressing spectrum issues and pricing strategy [February 2012]

E.1   Introduction

If the spectrum resource is to be used efficiently and effectively, the sharing of the available spectrum has to be coordinated among users in accordance with national regulations within national boundaries and in accordance with the ITU Radio Regulations (RR) for international use.

The ability of each nation to take full advantage of the spectrum resource depends heavily on spectrum managers facilitating the implementation of radio systems, and ensuring their compatible operation. Furthermore, the imbalance between the demand for radio frequencies and the availability of spectrum keeps growing, especially in urban areas.

According to economic theory, when demand exceeds supply, a price system should be implemented. As the frequency spectrum is a scarce resource, decisions concerning spectrum management should also consider the economic point of view. Therefore, to improve national spectrum management all available means including economic methods are needed.

E.2   Economic methods

Based on ITU Report ITU-R SM.2012-1 "Economic aspects of spectrum management"[80], there are three main regulatory reforms that encompass economic aspects of spectrum management:

1. Deregulation - relaxation of rules governing spectrum access
2. Delegation - transferring of certain spectrum management functions from government to the private sector
3. Use of the pricing mechanism - ensuring economically efficient use of spectrum

E.2.1   Administrative cost recovery price

Simplest method for spectrum pricing (already adopted by many countries) is the Administrative Cost Recovery Price (ACRP) that is based on estimation of the funding required to recover the yearly costs incurred by the government agency for managing the spectrum resource. This has major disadvantages i.e. the fees designed to recover administrative costs not tied to the value of the spectrum used also, may not stimulate spectrum efficiency.

E.2.2   Spectrum price determination based on system performance

This is based on the amount of spectrum used, number of channels or links used, degree of congestion, efficiency of radio equipment, transmitter power/coverage area, geographical location and other technical parameters for measuring the spectrum volume used or to define the "pollution area" of a radio system as a common basis for establishing spectrum fees.

E.2.3   Cost of shifting existing users to alternative frequency band

In another approach, spectrum fee is based on the costs when existing users have to be shifted to an alternative frequency band in the short term (few years).

Such reallocation should be financed by interested parties, in particular by the manufacturers of the new equipment and operators of new systems.

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[80]   www.itu.int/pub/R-REP-SM.2012-3-2010

Such an approach is very reasonable and indirectly improves spectrum efficiency since the new technology will use the band more efficiently and be of more benefit to society. This is an effective way to free spectrum from incumbents, particularly where military uses are concerned.

E.2.4   Spectrum price determination based on use of shadow prices

Economic definition of shadow price:

"a competitive price for a resource that would be established in an open market if there are many buyers in the market, none possessing any monopoly power to elevate the price of the resource by withholding the resource from the market".

E.3   Basic principles for financing national spectrum management and establishment of fee system

The following principles should be adhered to when establishing any fee system.

E.3.1   Legal principles

a)   The radio-frequency spectrum is the property of the State. Thus, any spectrum occupancy relating to non-governmental activities is considered to be private occupancy.

b)   Belonging as it does to the public domain of the State, the spectrum must be managed in the interests of the national community as a whole.

c)   As the owner of the spectrum, the State has the right to require private occupants thereof to pay spectrum fees (known also as spectrum occupancy fees, frequency availability fees or spectrum usage fees, or simply as fees where there is no ambiguity).

d)   The planning, management and monitoring of the spectrum are carried out by the State or by entities to which the State has delegated such responsibilities. Those activities, together with the corresponding equipment and investment, are essential to ensuring that the spectrum is used under satisfactory conditions.

e)   It is therefore lawful for the authorities to require, moreover, that private spectrum occupants also pay administrative fees (known also as frequency management fees or service fees, as well as administrative charges or, where there is no ambiguity, simply as charges) to cover all of the costs arising out of spectrum planning, management and monitoring activities.

f)   The establishment of spectrum fees and administrative fees must be carried out with due respect for the rules of transparency, objectivity, proportionality and non-discrimination. Where transparency is concerned, it is particularly important that the rules governing the establishment of fees be simple and readily understandable by all concerned.

g)   The rules governing the establishment of fees must be relatively stable over time in order to provide spectrum occupants with the necessary visibility and legal security.

h)   In return for the fees they pay, users of assigned or allotted frequencies enjoy protection under the relevant provisions of the regulations in force. By contrast, users of freely accessible frequencies (used, for example, for low-range and low-power sets, WiFi, Bluetooth, amateur radio and radio-controlled models) are not protected and should therefore not be required to pay fees. A reality principle unites with this legal principle to dictate that fees should not be applied to freely accessible frequencies.

E.3.2   Economic principles

a)   The frequency spectrum is a limited and, in some cases, scarce resource. The main objectives of the manager are to secure both optimum spectrum occupancy and effective frequency utilization.

b)   The reasons for spectrum fees and administrative fees, and the ends to which they are put, are different. That difference should thus be reflected in two distinct approaches for establishing each kind of fee.

c)   The sole purpose of administrative fees should be to pay for the service rendered by the authorities.

d)   By contrast, the purpose of spectrum fees is multifaceted in that they must:

–   enable achievement of the budgetary objective set by the authorities;

–   not clash with the economic objectives of the authorities in regard to national development and the development of new services;

–   take account of all the benefits that occupants derive from the spectrum;

–   constitute a tool for spectrum management.

e)   Fees constitute financial resources for the State and for the spectrum manager. The level at which they are set should systematically take account of inflation and the evolving status of the spectrum manager's budget.

E.3.3   Spectrum pricing factors

There are many factors related to spectrum pricing. Some can be calculated or at least estimated and the others need not to be considered. Table E.1 shows these factors divided into two categories.

Table E.1: Technical and non-technical factors

Technical factors	Non- technical factors
National Table of Frequency Allocation	Population density
Occupied Bandwidth	Radio Stations Density
Number of Frequency Channels	GDP
Polarization	User's income
Service Area	Duration of use
Coverage Area	Inflation
Power (EIRP)	Type of Radio Licence
Antenna Height	Geographical and Regional issue
Antenna Pattern	Interconnections among International users
Modulation	
Type of Radio Service	
Service priority	
Type of Radio Application	
Quality of Service	
Coordination	

While the spectrum must be managed in the interests of the national community as a whole, the radio-frequency spectrum is the property of the State and therefore, any spectrum occupancy relating to non-governmental activities is considered to be private occupancy.
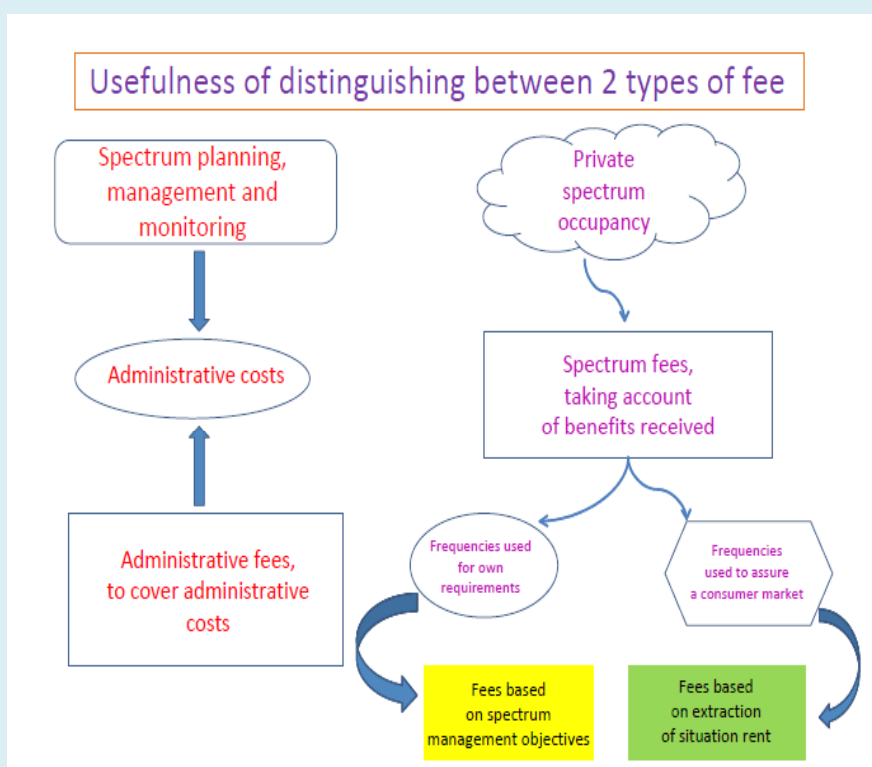
E.3.4   Spectrum fees

As the owner of the spectrum, the State has the right to require private occupants thereof to pay spectrum fees (known also as spectrum occupancy fees, frequency availability fees or spectrum usage fees, or simply as fees where there is no ambiguity).

E.3.5 Administrative fees

The planning, management and monitoring of the spectrum are carried out by the State or by entities to which the State has delegated such responsibilities. Those activities, together with the corresponding equipment and investment, are essential to ensuring that the spectrum is used under satisfactory conditions.

It is therefore lawful for the authorities to require, moreover, that private spectrum occupants also pay administrative fees (known also as frequency management fees or service fees, as well as administrative charges or, where there is no ambiguity, simply as charges) to cover all of the costs arising out of spectrum planning, management and monitoring activities.

Figure E.1: Spectrum planning, management and monitoring

Source: ITU

The establishment of spectrum fees and administrative fees must be carried out with due respect for the rules of transparency, objectivity, proportionality and non-discrimination. Where transparency is concerned, it is particularly important that the rules governing the establishment of fees be simple and readily understandable by all concerned.

The rules governing the establishment of fees must be relatively stable over time in order to provide spectrum occupants with the necessary visibility and legal security.

In return for the fees users of assigned or allotted frequencies enjoy protection under the relevant provisions of the regulations in force.

The reasons for spectrum fees and administrative fees, and the ends to which they are put, are different. That difference should thus be reflected in two distinct approaches for establishing each kind of fee.

The sole purpose of administrative fees should be to pay for the service rendered by the authorities.

By contrast, the purpose of spectrum fees is multifaceted. In that they must enable achievement of the budgetary objective set by the authorities; not clash with the economic objectives of the authorities in regard to national development and the development of new services; take account of all the benefits that occupants derive from the spectrum; constitute a tool for spectrum management.

Fees constitute financial resources for the State and for the spectrum manager. The level at which they are set should systematically take account of inflation and the evolving status of the spectrum manager's budget.

E.3.6   Establishment of administrative charges[81]

Administrative charges are intended for covering the cost of spectrum planning, management and monitoring. The management function includes activities relating to the issuance of licences and authorizations for spectrum use and to the establishment and collection of the corresponding fees.

Administrative costs are made up of staff costs, operational costs and the costs (amortization) of buildings and equipment corresponding to the aforementioned activities.

E.3.6.1   Rule for the allocation of administrative costs

The annual administrative costs are in proportion to fee payer's respective turnover.

Thus, for a fee payer whose turnover is equal to CA, the annual amount of the administrative fee Ra for the year in question is equal to the following product:

$$Ra \; \frac{administrative\ costs\ for\ the\ year\ in\ question}{sum\ of\ the\ turnovers\ of\ each\ of\ the\ fee\ payers\ for\ the\ year\ in\ question} + CA$$

E.3.6.2   Spectrum fees for frequencies used in the provision or marketing of services intended for a consumer market

Generally speaking, the fees applied in respect of the above frequencies constitute the major part of the budgetary revenue that the State receives by way of spectrum-related fees.

To reflect the income derived from the situation rent, various factors may be envisaged, such as the population covered by the licence, the portion of territory concerned by the licence, or turnover resulting from the provision or marketing of the services.

It is very often the turnover that proves to be the most representative factor in terms of the situation rent. If the turnover is to be used as the basis for fee calculation, it is recommended that its perimeter and content be clearly defined.

E.3.6.3   Fees applied for 2G mobile service

The following equation could be used for determining the annual amount Rs of the spectrum fee:

$$Rs = F + t\% * CA$$

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[81]   Source: Guidelines for the establishment of a coherent system of radio-frequency usage fees - ITU-D STUDY GROUP-2, 4th STUDY PERIOD (2006-2010) - www.itu.int/pub/D-STG-SG02.FEES-1-2010

Where:

F represents a fixed amount to be paid each year. This amount may be proportional to the total bandwidth allocated to the operator in question for the 2G service.

CA represents the turnover of the operator for the corresponding year in respect of the 2G mobile service frequencies.

t% represents the percentage to be levied on the operator's turnover. Generally speaking, the t% applied by administrations is 1% or close to 1%.

E.3.6.4   Fees applied for 3G mobile service

The following equation could be used for determining the annual amount Rs of the spectrum fee:

$$Rs = t\% * CA$$

Where:

CA represents the operator's turnover for the corresponding year in respect of the 3G mobile service frequencies.

t% represents the percentage to be levied on the operator's turnover.

To this annual fee is added an "entry ticket", payable upon allocation of the licence.

For the 3G case, the fixed amount has been replaced by the `entry ticket' that is proportional to the allocated bandwidth and payable upon allocation of the licence.

The Guidelines for the establishment of spectrum fees take into account the economic and budgetary objectives of the authorities, recognition of the benefits derived from spectrum occupancy - that depend on the use that the occupants make of the frequencies allocated to them, allocated bandwidth, area of the allocation surface, location within the spectrum of the allocated frequency band, etc.

The application of an "entry ticket" or excessively high annual fees during the introduction phase of a new radiocommunication service involving significant investment, could have the effect of reducing the investment capacity of the operators concerned.

The amount of the `entry ticket', which may be proportional to the allocated bandwidth, as the case may be, should not hamper the deployment of new entrants' networks.

E.4   Market based assignment approach: Auctions

In an auction, licences are awarded by bidding among competing spectrum applicants. Auctions award licences to those who value them most highly while simultaneously generating revenues for the spectrum authority.

However, as is the case with an unrestricted spectrum market, auctions may raise competitive concerns if not combined with an active competition policy and limits on how much spectrum an entity may purchase.

Market forces do not ensure economic efficiency or maximize consumer welfare in markets that are not competitive because a dominant service provider or group of providers have market power.

E.4.1   Transferable and flexible spectrum rights

While auctions are the assignment mechanism best suited to providing an initial economically efficient distribution of the spectrum resource, they will not ensure that spectrum continues to be used in an economically efficient manner in the future.

As with other resources, economists recommend that spectrum users be allowed to transfer their spectrum rights (whether assigned by auction or some other assignment mechanism) and that spectrum users have a high degree of flexibility in the choice of the consumer services that they provide with their spectrum.

E.4.2 Advantages and disadvantages of auctions and transferable spectrum rights

Auctions have the advantages of awarding licences to those who value them most highly, while simultaneously generating revenues. When auctions are used to assign licences within a given allocation structure, licences are awarded to those who value them the most only within the confines of the allocation structure.

Other expected benefits associated with auctions may be fairness, transparency, objectiveness, and the speed with which licenses can be awarded. Auctions can reduce the opportunities for favouritism and corruption in the competition for spectrum, promote investment, and promote technological advancement.

However, in order to promote competition, it may be necessary to impose additional safeguards, for auctioned services. For example, in some situations some or all of the potential bidders may be dominant service providers who are endeavouring to strengthen their monopoly positions.

Restrictions on eligibility to participate in an auction or limits on the amount of spectrum that any entity may win can alleviate this problem, although this may limit the number of participants.

E.5 Types of auctions

Auction is increasingly being used among new technologies and services such as IMT.

The license(s) can be assigned on the basis of a so-called 'open bidding' or public process, with bids visible to other parties, or on a 'sealed tender' system, under which each party marks a single private offer; there are numerous alternative variants of open auctioning.

The auction can have a minimum acceptable bid or 'reserve price'.

The choice of auction mode will vary with the nature of licenses made available, the number and nature of firms with an interest in theirs and the regulator's or government's objectives.

There are a number of trade-offs between, for example, the advantages which an open auctioning system has in spreading knowledge among firms about other firms' valuations, hence encouraging higher bidding, and the opportunities for collusion among bidders which the communication present in open auctioning may facilitate. As a result, each set of circumstances tends to require an individual solution.

The experience of other jurisdictions and the pros and cons various spectrum auction designs including[82]:

- English Auctions or Simultaneous Ascending Auction (SAA) – where blocks of spectrum are awarded to the highest bidder remaining who has exceeded the opening price set by the regulator;
- Dutch Auctions – where the ultimate price paid is determine after succeeding descending rounds from an initial high price set by the regulator;
- First-price sealed-bid Auctions – where participants submit their bid without any information on prices and the highest bidders wins;
- Second-price sealed-bid Auctions – similar to the previous method except the second highest price is selected;

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[82] Refer to www.acma.gov.au/WEB/STANDARD/pc=PC_300178

- Simultaneous Ascending Auction (SAA) sealed-bid hybrid Auctions – where SAA is used in the first several rounds and first-price sealed-bid is used in the final round.
- Simultaneous multi-round ascending auctions: This format is used when there are many spectrum lots to be allocated together across a range of different geographic areas and there are different band segments.

All lots are simultaneously on offer over multiple rounds of bidding. Bidders may bid on any lot or combination of lots in each bidding round. At the end of each round high bids are disclosed and all bidders can bid again in the next round to become the high bidder. In general, after a round with no more bids, the bidders holding the high bids in the previous round win the lots.

E.6   Spectrum issues and pricing strategy

For the terrestrial component of International Mobile Telecommunications (IMT), the following frequency bands are typically identified by governments and regulators for the purposes of IMT:

Band (MHz)
450 - 470
698 – 806* / 790 – 862*; 806 - 960*
1710 – 1885, 1885 - 2025
2 110 - 2 200
2 300-2 400
2 500-2 690
3 400-3 600

* 790-862 MHz (Allocation for Region 1 and 3)
698-790 MHz (Allocation for Region 2 and 9 countries in Region 3: Bangladesh, China, Rep. of Korea, India, Japan, New Zealand, Papua New Guinea, Philippines and Singapore).

For all IMT frequency bands identified in the Radio Regulations, there is a need to establish suitable 'national footnotes' for National Frequency Allocation Plans (NFAP). These would explicitly define the usage of IMT frequency bands and the basis for their sharing by different operators and also sharing with other radio services.

E.6.1   Use of lower frequency bands for IMT services

Lower frequency bands in the sub-1 GHz range have better building penetration and smaller foliage loss, as well as having larger coverage and being more cost than higher frequency bands. While 2.3 and 2.6 GHz bands are useful for IMT applications, lower frequency bands are better suited to larger cities and population hubs.

IMT advanced technologies can now be implemented at lower bands and 700 MHz is proving to be most effective for deployment in rural or high-cost regions. It is also economically viable – an LTE network at 700 MHz would be 70 per cent cheaper to deploy than an LTE network at 2.1 GHz (GSM Association). Two to three times less sites are required for initial coverage at 700 MHz as compared to 2.1 or 2.5 GHz.

Figure E.2: Comparison of cell site coverage[83]

	700 MHz Propagation	1800 MHz Propagation	2400 MHz Propagation
Total Network Cost per cell	$150,000	$600,000	$1,500,000
Network Cost per Customer	$65	$180	$1820
# Months to network cost breakeven	9 Months	36 Months	91 Months

700 MHz Coverage · 1800 MHz Coverage · 2400 MHz Coverage

Source: www.alohapartners.net

The relative Capex as well as the cell radius favour the use of 700 MHz as compared to higher frequency bands.

WRC-07 developed WRC-12 agenda item 1.17 to consider the results of sharing studies between the mobile service and other services in the band 790-862 MHz in Regions 1 and 3, in accordance with Resolution 749 (WRC-07), to ensure the adequate protection of services to which the frequency band is allocated. Later this month (17th Feb. 2012) the WRC -12 make available its conclusions on this agenda item.

E.6.2   Frequency arrangements in the band 698-960 MHz

Preliminary Draft Revision (PDR) of Recommendation ITU-R M.1036-3, "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications-2000 (IMT-2000) in the bands 806 960 MHz, 1 710-2 025 MHz, 2 110-2 200 MHz and 2 500 2 690 MHz" was discussed at the 12th meeting of Working Party 5D Goa, India, 12-19 October 2011.

The PDR ITU-R Rec 1036-3 has been revised by ITU-R Study Group-5 and the revision is under approval through consultation for which circular letter CAR/ 329 has been issued by Radiocommunication Bureau (BR).

The frequency arrangements in the band 698-960 MHz, contained in the PDR (as revised) is shown in Figure E.4.

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[83]   See www.alohapartners.net

Figure E.3: Relative Capex
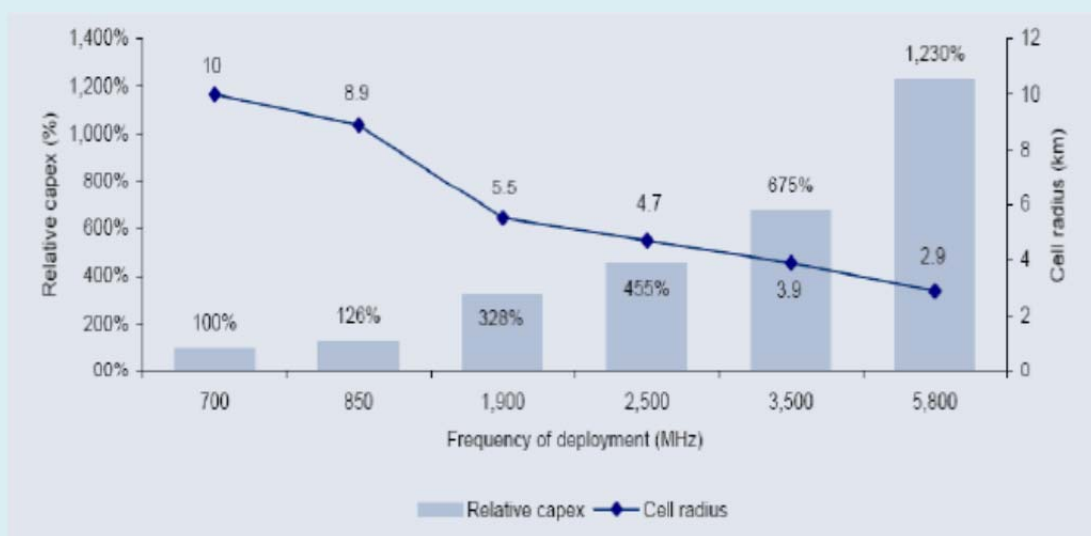
Source: Windsor Place Consulting, 2010

In the arrangement A3 (Figure E.4) - reversed duplex direction (mobile transmit in upper band and base transmit in lower band) provides better conditions for coexistence with the lower adjacent broadcasting service.

In arrangement A4, administrations can use the band solely for FDD or TDD, or some combination of FDD and TDD. Administrations can use any FDD duplex spacing or FDD duplex direction. However, when administrations choose to deploy mixed FDD/TDD channels with a fixed duplex separation for FDD, the duplex separation and duplex direction as shown in A4 are preferred.

For arrangement A5, 2 x 45 MHz FDD arrangement uses sub blocks with dual duplexer solution and conventional duplex arrangement. Internal guard bands of 5 MHz and 3 MHz are provided at the lower and upper edge of the band for better co-existence with adjacent radio communication services.

Arrangement A6, taking into account the external 4 MHz guard band (694-698 MHz), a minimum internal guard-band of 5 MHz at the lower edge (698 MHz) and 3 MHz at the upper edge (806 MHz) needs to be considered.

E.6.3   National Frequency Allocation Table (NFAT) and bands identified for IMT

In the national context and as a part of State rights and obligation it is up to the State, or a delegated regulatory authority, to allocate frequency bands. The managing authority draws up the national frequency allocation table and the national frequency register listing frequency assignments and keeps them up to date.

Allocations are to be listed in a national frequency allocation table, which shall indicate, for each frequency band and, as required, the authorized services with the corresponding authorized categories (according to the definitions contained in RR Article 1) and user categories. The table shall also specify user rights and obligations (such as exclusive use, sharing with equal rights or with priority, etc.).

A national table of frequency allocations is a basic tool for an efficient spectrum management process. It provides a general plan for spectrum use and the basic structure to ensure efficient use of the spectrum and the prevention of RF interference between services.

Through use of the table, manufacturers will have a guide to where in the spectrum to design and build equipment and users will know where to operate. As described in the handbook "National Spectrum Management", the International Table of Frequency Allocations (Article 5 of the Radio Regulations) forms the basis for national tables and in some countries this may be used as the national table.

Figure E.4: Frequency arrangements in the band 698-960 MHz

Source: ITU
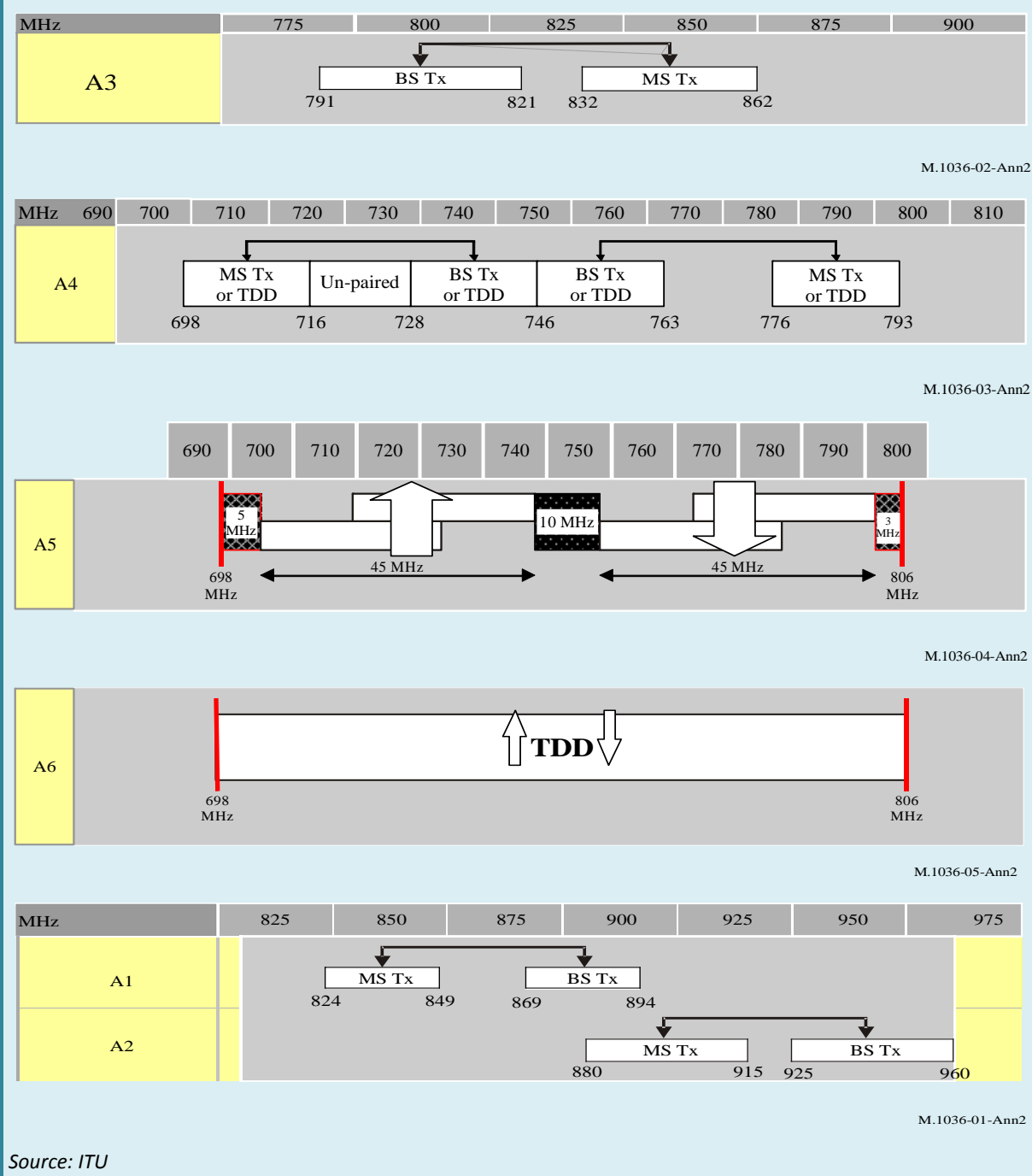
Nevertheless, other countries have included additional information on national use varying in detail from showing which service operates when the Radio Regulations offer a choice, to spectrum available for government and non-government use, and, for specific sub-bands, channel arrangements and equipment specifications in use.

As part of 'Guidance on the regulatory framework for national spectrum management', ITU had sought responses from administrations to the question ` Is there a national table of frequency allocations? Yes or No.' Responses from 73 administrations showed that 93 per cent have a national allocation table. The score for the countries of Europe is 100 per cent.

National frequency allocation plans that have not been updated in recent years will lack many of the details in Article 5 of the Radio Regulations Edition 2008 (latest edition – the Final Acts of the WRC-12 were released on 17 February 2012 at the conclusion of the WRC-12).

E.6.4   Spectrum auctioning

E.6.4.1   International situation

There is a growing pressure on governments and regulators to make increasingly large portions of spectrum available to the mobile industry to meet its spectacular growth. Regulators all over the world are faced with the underlying question about spectrum: how much is it worth?

In purely financial terms, one can establish the value of a discrete block of spectrum by putting it up for sale and seeing how much anyone is willing to pay to use it.

Broadband services have pushed traditional spectrum assignment processes into obsolescence, leading more governments to overhaul their licensing approaches.

Three basic spectrum management models – command-and-control, property rights and commons – have existed for essentially all of the past two decades of policy change in spectrum management.

While many regulators continue to apply a 'command-and-control approach' to allocation of spectrum, the 'Flexible rights of use' model is applied to typical uses such as 2G and 3G mobile services.

Following the 'Flexible rights of use' model, many administrations have chosen to auction the spectrum.

The appropriate price for spectrum will depend on how advanced the country's economy is and the socio-economic status of the population. Prices that are set too high will prevent uptake of wireless broadband services and will reduce the value of spectrum. Likewise, prices that are set too low may potentially lead to an inefficient allocation of spectrum.

Using spectrum pricing and fees from other administrations in a given region, an appropriate benchmark for spectrum pricing can be found by observing the policies of other nations with comparable GDP per capita.

Elsewhere in the world there are examples of the exercise of this 'flexible rights of use' model for spectrum management.

France, Sweden, Finland, Switzerland, and the UK, all dedicated spectrum in the 790 MHz-862 MHz band (known as the 800 MHz band) for wireless services. The UK plans to auction spectrum in the 800 MHz and 2.6 GHz bands in 2012; meanwhile, unlike some other European countries, it is permitting 2G operators to re-farm the 900 MHz band for 3G offerings.

In USA, FCC completed the auction of spectrum in the 700 MHz band in March 2008. Spectrum allocated to a variety of providers mainly via a technology-neutral approach.

E.6.4.2   Situation in developing countries

For many developing countries, spectrum management and regulatory frameworks require strengthening on many fronts. This may require improved coordination between governments and regulators as well as service providers. Importantly the primary and secondary level regulations – those that form the essential attributes of a spectrum management system – need reinforcement. Consideration needs to be given to the formulation and implementation of best practice guidelines for the management of spectrum.

While existing service providers benefit from the band allocation plans by regulators for IMT services, where these providers are in a position of market dominance regulators should take steps to address any clear a lack of competition for mobile services. Plans to auction spectrum for IMT services and the possibility of new entrants would enhance competition and improve quality of service. The proposition could be more attractive with auctions taking place for spectrum in the lower frequency bands – for example 790-862 MHz band. However, before auctions for spectrum take place there is a need to consider carefully the optimal approach to secure and maintain competitive tension in relation to the spectrum. This could be done by first auctioning a new telecommunications licence, for example with 900 MHZ (including perhaps the ability to utilize W-CDMA @ 900 MHz). Undertaking such an auction would be sensible for a voice-centric developing market and the availability of equipment and devices to utilise the 700 MHz spectrum band for wireless broadband devices.

For the auction governments and regulators may consider frequency bands not presently used in the 900 MHz or the vacant band 790-862 MHz. Other bands like 2500-2690 MHz could also be considered for auctioning. For competition and fairness, all service providers, including incumbents should pay spectrum fee. As described above, prices should be set with reference to appropriate global and regional benchmarks.

In some cases there may be certain limitations in the relevant telecommunications legislation which mean that any auction of spectrum would need to be by way of the granting of a separate telecommunications licence. Optimally going forward, amendments should be made to the relevant Act or Regulation to provide flexibility in the issuing of spectrum licences including by price based selection mechanisms such as auctions.

E.6.4.3   Rural connectivity and use of satellite option

Using satellites in rural, remote and un-served areas as part of a national broadband solution could represent both good public policy and good commercial sense for some countries. High Throughput Satellites (HTS) especially in the 'Ka' band provide a true paradigm shift from the conventional use of 'Ku' and 'Ka' band satellites. There are 100 to 1 cost advantages since the satellite capacity increases 100 fold compared to today's conventional satellites.

These could be utilized to provide cellular network connectivity in areas without fibre, or microwave facilities or direct connectivity when mini BTS are not economic to use.

With the 'Spot beam technology' utilized by the HTS, downlink beams illuminate a smaller area of the order of 100s of kilometres instead of 1000s of kilometres. Honeycomb (cellular pattern on the illuminated service area) frequency reuse results in a drastic increase in the overall capacity of the satellite. This is analogous to comparing a DTH (Direct-To-Home) broadcast signal to a cellular phone signal. Faster speeds as well as smaller dishes with lower service upgrade costs, time zone sharing and geographical sharing, are added attributes that make HTS a viable option.

E.7   Summary and conclusions

Spectrum pricing is a national subject and there isn't a universal methodology suitable for all countries and member states. However, there are some principles that can be taken into account to reach more accurate results in estimating the value of spectrum and cost recovery of spectrum management. While this is so, certain steps on a national level would help in meeting the desired objectives.

Where 700 MHz band spectrum has not been made available for IMT services, governments and regulators should expedite the process and ensure that the appropriate regulatory frameworks are in place as soon as possible.

In some cases support for WiMAX in 2.3 GHz band is acknowledged and is being actively pursued, and the appeal of using a lower frequency band for rural and underserved areas, with over 80 per cent of the population, is indeed very attractive.

Despite starting two years later than WiMAX 2, TD-LTE has now emerged as a viable alternative. TD-LTE commercial service has been launched in Brazil, Japan, Poland, Saudi Arabia, and other countries. TD-LTE deployments are underway in Australia and Scandinavia and large-scale TD-LTE networks are planned in the United States and India. The frequency bands used by TD-LTE are 3.4–3.6 GHz (Australia) 2.57–2.62 GHz in the USA and China and 2.3–2.4 GHz in India and Australia.

Developing countries can consider factoring in TD-LTE in their band allocation plans since it was only two years ago that most of the WiMAX operators, including operators with unpaired TDD frequency spectrum, were planning to deploy WiMAX 2 in practice. Today, most of them are switching plans and are deploying TD-LTE instead.

As highlighted in section E.6.3 above, the National Frequency Allocation Table must be updated. It is a very important national document on which depends the growth of wireless services in general and wireless broadband services in particular.

A computer record of the 'National Frequency Register' is mandatory and this must include government and private user records. For those countries that have not implemented market-based pricing for spectrum, the possibility of an auction means it is incumbent on the government and regulator to ensure that the auctioned bands are free of any present use – if discovered at a later stage these can pose migration issues and unnecessary legal wrangles.

An understanding of the ITU International Frequency Information Circular (IFIC) for Terrestrial Services[84] is essential for regulators and policy makers dealing with frequency matters. Keeping up-to-date with the ITU publication (following the WRC and the Radiocommunication assembly) is vital for those responsible for this area. Participation in ITU activities on a regular basis is also recommended.

Where competition is lacking, consideration should be given to facilitating entry of a new entrant as part of the plan to accelerate wireless broadband services in developing countries. Given the dominant position of mobile services now (which will grow even more so) and wireless broadband in the future, the need to utilize key spectrum below 1 GHz spectrum resources (especially the 700 MHz band) is profound.

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[84] www.itu.int/pub/R-SP-LN.IT/en

Appendix F: Summary of recent Ofcom spectrum papers

In February 2011, consultants Real Wireless prepared a study entitled Report for Ofcom: 4G Capacity Gains[85] for the United Kingdom telecommunications regulator, Ofcom, on issues associated with the capabilities and potential of 4G technologies as well as topological improvements to wireless networks that will be necessary to expand supply in the medium term.

Ofcom initiated the study as the exponential growth in mobile broadband penetration has prompted it to examine and which necessary rectify growing capacity concerns associated with the use of scarce spectrum.

The study makes a number of significant observations and arguably dispels conventional wisdom about certain issues relating to the gradual succession of 4G technologies over 2G and 3G services. It states that previous studies on 4G network-capacity improvements over 3G heavily rely on the accuracy of forecasting models, the accuracy of such previous forecasting is open to question. Furthermore, the study emphasises the importance of network topology to improving capacity. In their view this would take the form of more numerous cells, smaller cells and wireless offloading techniques.

The study examines the likely capacity improvements of 4G relative to 3G over a 10-year timeframe. It concludes that technological improvement arising from 4G efficiencies will not be sufficient to keep pace with demand growth. Extremely high peak data rates (from 150 – 1200 Mbit/s with LTE) will surpass the 4G efficiency dividend. In short, the demand for data generated by 4G's high speeds will eclipse its ability to use spectrum more efficiently. It is estimated that there will be spectrum improvement of between 1.2 x and 3.3 x (pending release of LTE Advanced).

Peak Efficiency | **Peak Data Rate**
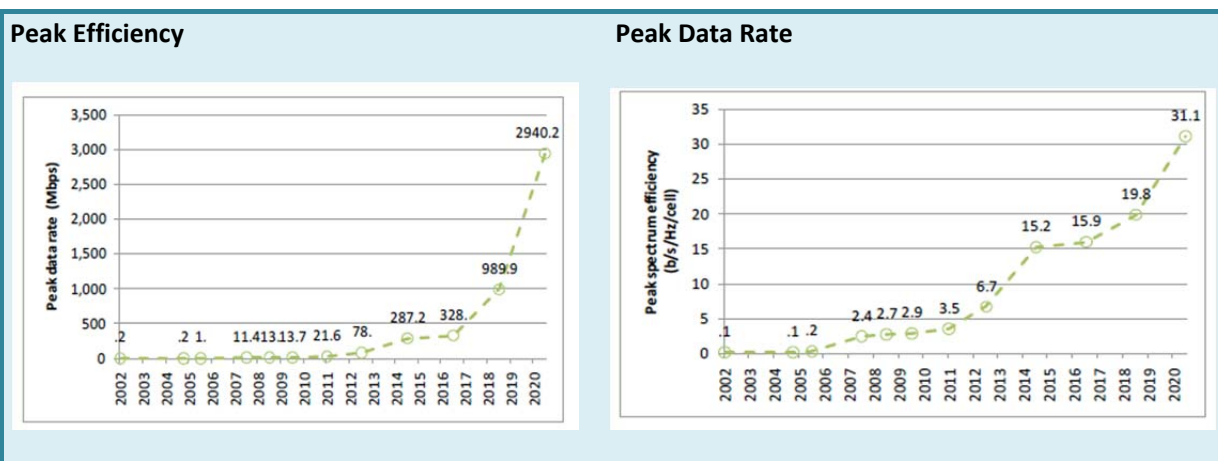
In relation to quantifying spectrum efficiency, the study recommends employing a discount factor to take into account the experience in real-world networks. This is because in practice networks are loaded below 100 per cent levels due to the need to ensure required quality of service standards in cellular areas.

The study highlights the importance of topological improvements in enhancing spectrum efficiency. Topology is important as network capacity is not evenly distributed across its cells. Each cell possesses different user characteristics and varying qualities of service. While legacy networks have traditionally been built around macrocells, microcell infrastructure has been in-built in 4G networks from an early stage. The consultants find that in dense and hyper dense urban areas, a significant proportion of cellular infrastructure will likely be femtocells / WiFi and microcells. The study demonstrates that such topology will enhance network capacity through identifying three scenarios that are conducive to microcellular deployment including major London train stations.

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[85]   Version 1.5, 27 January 2011

However, a potential tripping point for these solutions is that operators may be dissuaded to upgrade topological infrastructure due to the belief that insufficient revenues generated will not justify the costs involved in upgrades.

The impact of 4G technologies on network performance is examined in greater granularity than previous research that has mainly taken a holistic view of wireless networks. In this paper, 4G improvements relating to capacity gains are viewed within the context of local demand and bottlenecks.

The study compares the relative spectral efficiency of specific 3G and 4G technologies. It is noted that efficiency will improve at a faster rate in the short to medium term given the increasing commonality of 3G HSPA+. User terminals are assigned one of the following three categorisations:

   i.   Low End Devices – one antenna increasing to two antennas in future releases (e.g. Entry level or featurephone type handsets);

   ii. Typical devices – two antennas, may increase to four at the end of the 10-year timeframe (e.g. Smartphones, dongles and M2M devices); and

   iii. High end devices – two antennas increasing to four antennas in future releases and may increase to eight antennas at the end of the timeframe (e.g. laptops, iPads/MIDs).

High-end devices release the greatest spectral efficiency benefits while improvements are much more modest for low-end and typical configurations.

The study conducts an analysis into how spectrum efficiency of 4G will translate into tangible capacity improvements in dense urban areas over a 10-year timeframe. Practical constraints and technological availability are taken into consideration. Over a seven to eight year period, the majority of wireless base stations are projected to comprise of two-antenna deployments (50 per cent). The adoption of feature and entry-level handsets will be largely replaced by smartphones, and other M2M devices. As a result of the evolution path from WiMAX to WiMAX 2 and LTE to LTE-A, it is expected that spectral efficiency will increase from 1.5 bps/Hz in 2014 to 2.4 bps/Hz in 2020.

In light of the above analysis, the study then determines whether these technology-based spectrum efficiency gains address high demand scenarios. It is noted that 'urban areas' experience bottleneck-causing demand clusters – a feature overlooked in previous surveys. The study considers that femtocells are viewed as being more effective in-door solutions (i.e. within a residential estate or apartment complex) to reducing bottlenecks. Within the context of a busy metropolitan area (such as a train station), smaller and more numerous cells will go a long way towards improving capacity, however, geographical limitations may result in bottlenecks in some circumstances.

The consultant points to several issues that it recommends should be taken into consideration by regulators and industry stakeholders that are anticipating spectral capacity constraints in the medium to long term:

   i.   the efficiency dividends from 4G services have likely been overstated given real-world practicalities and network limitations;

   ii. emphasis also need to be placed on topological improvements in the form of smaller and more numerous cells; and

   iii. despite the combination of the above two solutions yielding substantial improvements, there is a need for more spectrum to be allocated to these services to ensure that supply meets demand.

In closing, the study recommended that that previous studies into the dimensioning of future spectrum requirements for 4G networks should be revisited with the revised cell spectrum efficiency results recommended by this study. In addition, they suggested that further investigation of the role of changing topologies should be factored into future spectrum requirements.

Appendix G: Summary of 2011 ACMA spectrum papers

The Australian Media and Communications Authority (ACMA) has recently published two important papers (900 MHz Band Review and Towards 2020) on medium to long-term spectrum requirements for mobile broadband and a review of the opportunities available for the 900 MHz band. Comments are due in July 2011. ACMA states that work on the papers was initiated because of the convergence of broadcast, data and telecommunications services and exponential growth of mobile broadband usage, regulatory authorities around the world are coming to terms with the need to reassess spectrum allocation policies.

G.1   Planning for mobile broadband

G.1.1   Demand for mobile broadband spectrum in Australia

An underlying theme of the ACMA papers is the recognition of the need to accommodate explosive growth in mobile data services. Taking into account soon to be released digital dividend spectrum in the 700 MHz and 2.5 GHz bands (as well as previous releases in 850/900, 1800 and 2 GHz bands) 890 MHz of spectrum will be available for mobile broadband services by 2015.

However, ACMA predicts a thirty-fold increase in data demand between 2007 and 2015. Previous estimates have put the total amount of spectrum needed at 930 MHz. Without the release of additional spectrum, this 150 MHz shortfall will undoubtedly grow. ACMA projects that there will be a 500x increase in data demand from 2007 to 2020. As a result, ACMA believes that an additional 150 MHz of spectrum will need to be reallocated to accommodate the growth in demand. This is in addition to the existing allocation of spectrum for such uses as detailed in Figure G.1 .

Figure G.1: Growth in demand for mobile broadband spectrum in Australia
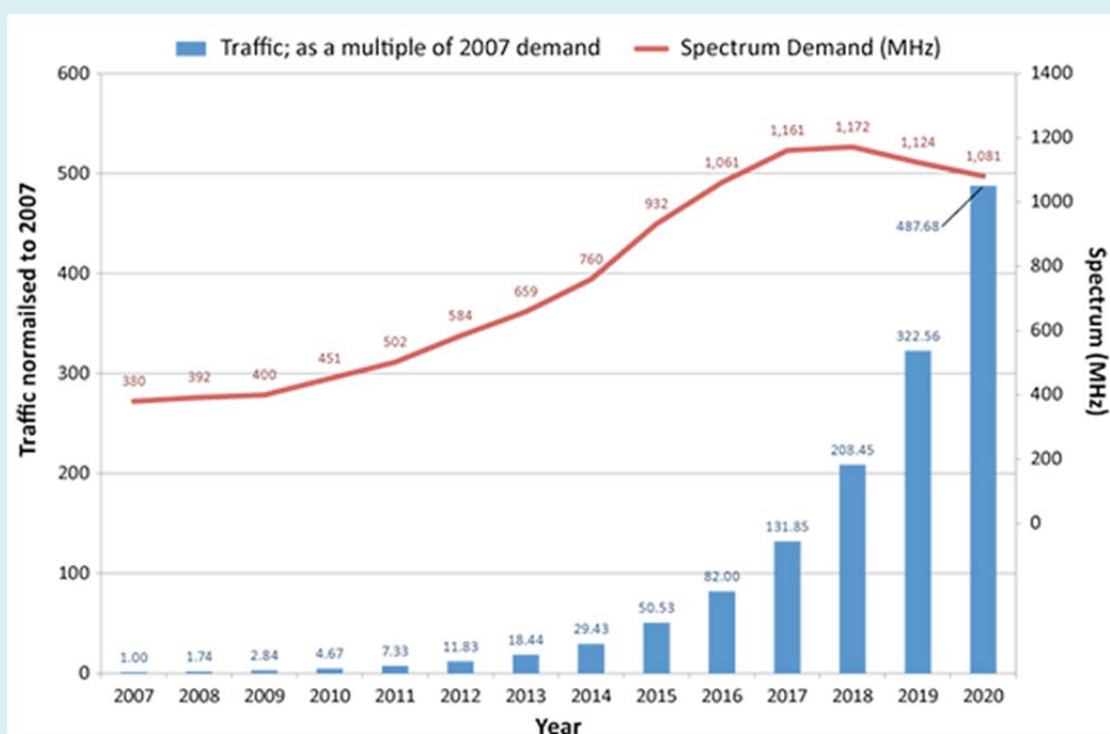
Source: ACMA 2011

Table G.1: Bands currently released or soon to be for IMT services in Australia

Band	Spectrum	Existing/Planned Usage
694-820 MHz	2 x 45 MHz	Digital dividend
825-845 and 870-890 MHz	2 x 20 MHz	Mobile telephony (3G- W-CDMA/HSPA)
890-915 and 935 to 960 MHz	2 x 25 MHz	Mobile telephony (2G-GSM900 and 3G-W-CDMA/HSPA)
1710-1785 and 1805-1880 MHz	2 x 75 MHz	Mobile Telephony (GSM1800) but only 2 x 15 MHz in regional areas
1900-1920 MHz	20 MHz	3G services
1920-1980 and 2110-2170 MHz	2 x 60MHz	3G mobile telephony and broadband
2302-2400 MHz	98 MHz	LTE Broadband
2500-1690 MHz[86]	2 x 70 MHz	Band under review to be auctioned in 2012. LTE Broadband
3425-3442.5 and 3475-3492.5 MHz	2 x 17.5MHz	Fixed wireless access, broadband
3442.5-3475 and 3542.5-3575 MHz	2 x 33.5MHz	Broadband
3575-3700 MHz	Up to 30 MHz	Fixed wireless access, broadband
TOTAL BANDWIDTH	**890 MHz**	

G.1.2 Solutions to address increased demand

ACMA states that spectrum efficiency and frequency reuse improve over time, due to technological improvements (i.e. the move from 3G to 4G networks) and network infrastructure deployment (higher density reduces the number of users per cell) this will not be sufficient to meet demand forecasts. As a consequence, ACMA is formulating plans to refarm candidate spectrum bands as detailed in Table G.2[87].

Table G.2: Future uses of candidate bands

Band	Current Use	Possible Uses
850 MHz	• Fixed / Mobile / Broadcasting	• LTE / LTE Advanced
1.5 GHz	• Fixed point-to-point • Fixed point-to-multipoint • Aeronautical	• W-CDMA – HSPA / HSPA+ • LTE / LTE Advanced • WiMAX TDD/FDD
Mobile Sat	• Mobile Satellite Services	
1675-1710 MHz	• Meteorological Satellite Services	• Will monitor FCC's progress. Indication that Met Sat services will be significantly affected by introduction of mobile broadband in this band.
2010-2025 MHz	• Fixed / Mobile	• LTE / LTE Advanced • W-CDMA – HSPA / HSPA+

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[86] The mid-band gap of 50 MHz will be converted to a spectrum licence for broadcasting services.

[87] The paper did not consider the 400 MHz, 2.5 GHz bands and Digital Dividend spectrum as these have already been subject to review.

Band	Current Use	Possible Uses
3.3 GHz	• Radiolocation	• FDD • TDD
3.4 GHz	• Fixed point-to-point • Fixed point-to-multipoint • Earth receive • Spectrum-licensed services	• WiMAX FDD/TDD • LTE / LTE Advanced
3.8 GHz	• Fixed point-to-point • Fixed point-to-multipoint • Fixed Satellite	• WiMAX FDD/TDD • WiFi (TDD) • LTE / LTE Advanced
4.2 GHz +		• Considering bands between 4.2 – 6 GHz • This spectrum is suited for in-home services and Femtocell offloading.

G.2 Future Uses of the 900 MHz band in Australia

G.2.1 Current arrangements

ACMA also issued second discussion paper on possible uses for the 820-960 MHz (900 MHz) band[88]. Comments are due in June 2011. At present, as summarised in the ACMA paper the 900 MHz band is allocated in Australia for a wide variety of uses as detailed in Table G.3.

Table G.3: Current uses of 900 MHz band

Usage	Description of Assignment	% of Band Allocated
CMTS (spectrum licensed segments)	• Licences are held by Telstra and Vodafone • Expire in 2013 • Not considered in this review.	57%
Digital CMTS (GSM segments)	• Allocated to enable operators to provide GSM services • Some carriers now are providing 3G UMTS services. • Allocated via apparatus assignment	31%
Point-to-point	• Operated under fixed licences • Principally for communications with one other fixed station. • Transmits sound broadcasting program material from a broadcasting studio to broadcasting transmitter.	7%
Land mobile	• Encompasses services that comprise of land / land mobile stations and communicate between other land / land mobile stations for aircraft / maritime stations.	4%

Other	• Includes:
	  o Point-to-multipoint
	  o Cordless telephones
	  o Sound-outside broadcast
	  o Industrial / scientific / medical
		2%

Source: ACMA, May 2011

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[88] Please note, this discussion did not include CMTS services of the 825 – 845 MHz and 870 – 890 MHz pairs.

G.2.2   Optimising scarce spectrum

ACMA highlights that several emerging technologies that improve spectral efficiency and should be considered for use on this band. The possibility of deploying 'smart infrastructure' including the creation of 'mesh networks' that relay information to a concentration point – with the information subsequently being transmitted to the next device. Such networks surmount spectrum usage problems associated with long distances.

ACMA also suggests that cognitive radio systems (CRS) and dynamic spectrum access (DSA) techniques are emerging smart radio technologies that facilitate the sharing of scarce spectrum. If developed, such technologies have the means of substantially altering the current spectrum-management framework.

G.2.3   Options for the 900 MHz band

In relation to the 900 MHz band, the ACMA paper identified several courses of action to address emerging capacity constraints. In particular:

- Licensing is identified as the most appropriate means to allocate spectrum in the 900 MHz band. Expanding auction arrangements presently in place for the 825-845 MHz and 870-890 MHz pairs to 805-825 and 870-890 MHz pairs using four 2 x 5 MHz FDD blocks have been highlighted. The ACMA paper also seeks submissions about using a combined approach via apparatus / spectrum licensing; and

- A change to the block sizing. Currently, in Australia the GSM900 bands (i.e. namely 890-915 MHz and 935-960 MHz) are currently being used by operators to provide 2G GSM services (specifically Optus and Vodafone provide 3G services with these pairs). Current arrangements stipulate that these allocations are to use blocks of 8.3 MHz spectrum. According to 3GPP standards for UMTS and LTE, 5 MHz blocks are recommended. ACMA believes that the inability of GSM to be an effective data platform, the commonality of 3G and the emergence of 4G technologies warrants a review into the reallocation of this spectrum into 5 MHz FDD blocks. A reduction in block size will enhance spectral efficiency.

The ACMA paper also discusses the possibility of expanding the 900 MHz band that will arise as a result the upper part of the 700 MHz band (17 MHz) being reallocated due to the migration to digital television. This spectrum is not harmonised with the remaining 'digital dividend' frequency. It is suggested that 2 x 15 MHz FDD spectrum could be paired with adjacent spectrum for CMTS services. Other possibilities, such as reserving the frequency for public protection and disaster relief are being considered in Australia.

ACMA has also recommended that 13 MHz of spectrum is reserved for cordless telephone services (CTS) and digital short-range radio (DSRR), a GSM-based technology supplanted by Bluetooth which have had low uptake and are near obsolete should be paired with digital dividend spectrum to facilitate FDD services.

Appendix H: Guidance for cross-border coordination for use of fixed and land mobile systems

H.1 Introduction

The management of potential inference between national radiocommunication systems requires successful coordination between governments. In the absence of regional agreements, governments must work together to insure the smooth operation of fixed and land mobile systems. In particular governments must protect the integrity of essential services such as radionavigation or emergency response networks.

For over three decades ITU has not performed any coordination between administrations on this issue, and as such this is a task that must be carried out by governments on a bilateral or multilateral basis. A number of administrations have developed specific agreements with their neighbours on using frequencies by fixed/mobile services to avoid mutual interference between stations of these services. Of particular importance are the ITU Radio Regulations (RR) which provide procedures for managing potential interference.

H.2 Radio Regulations (RR)

The ITU Radio Regulations[89] provide procedures for the following:

- coordination between administrations and the exchange of data;
- agreements between affected administrations;
- notification to ITU (sending data);
- ITU records in the Master International Frequency Register (MIFR).

ITU may give international recognition to certain frequency assignments.

No. 8.3 of the ITU Radio Regulations states: 'Any frequency assignment recorded in the Master Register with a favourable finding under No. 11.31 [of the Radio Regulations] shall have the right to international recognition.

For such an assignment, this right means that other administrations shall take it into account when making their own assignments, in order to avoid harmful interference.'

The Radio Regulations define varying degrees of interference, from permissible to harmful. Harmful interference is any interference that impacts on essential services, and eliminating this type of interference is a priority for governments. See Box H.1.

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[89] www.itu.int/pub/R-REG-RR/en

Box H.1: Extract from Radio Regulations – Section VII – Frequency sharing

1.166 Interference

The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.

1.167 Permissible interference

Observed or predicted interference which complies with quantitative interference and sharing criteria contained in these Regulations or in ITU-R Recommendations or in special agreements as provided for in these Regulations.

1.168 Accepted interference

Interference at a higher level than defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations.

1.169 Harmful interference

Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations (CS).

1.170 Protection ratio (R.F.)

The minimum value of the wanted-to-unwanted signal ratio, usually expressed in decibels, at the receiver input, determined under specified conditions such that a specified reception quality of the wanted signal is achieved at the receiver output.
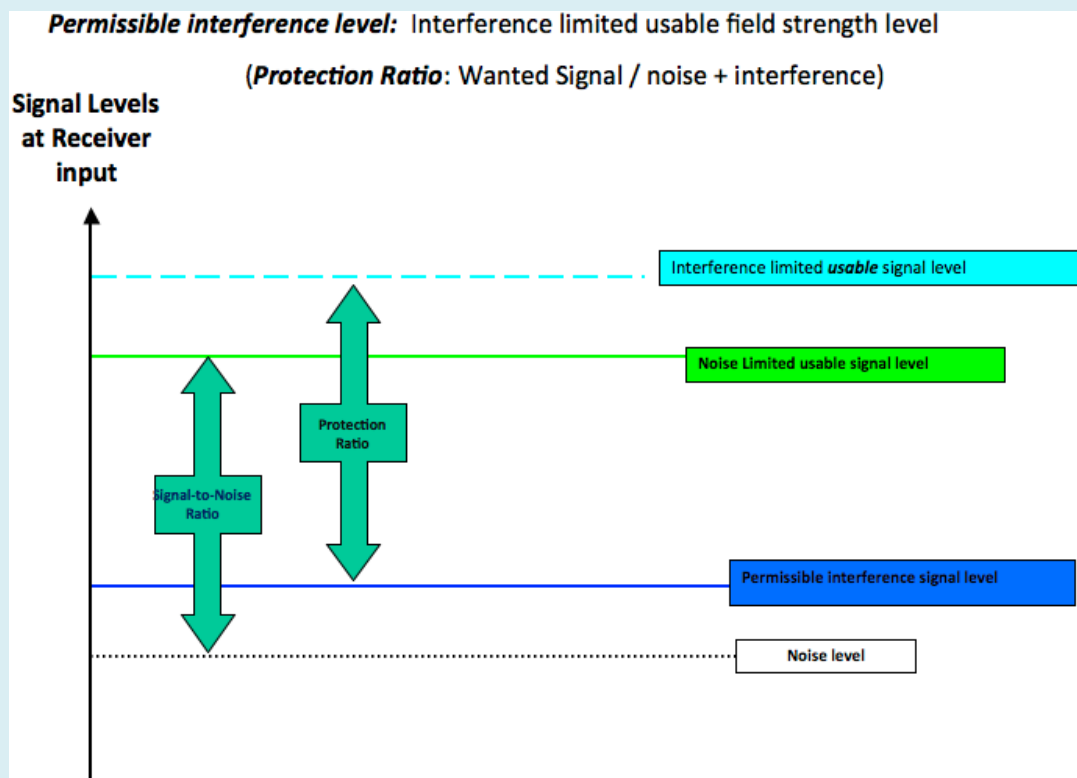
Figures H.1 to H.5 show signal-to-noise ratios for varying degrees of interference.
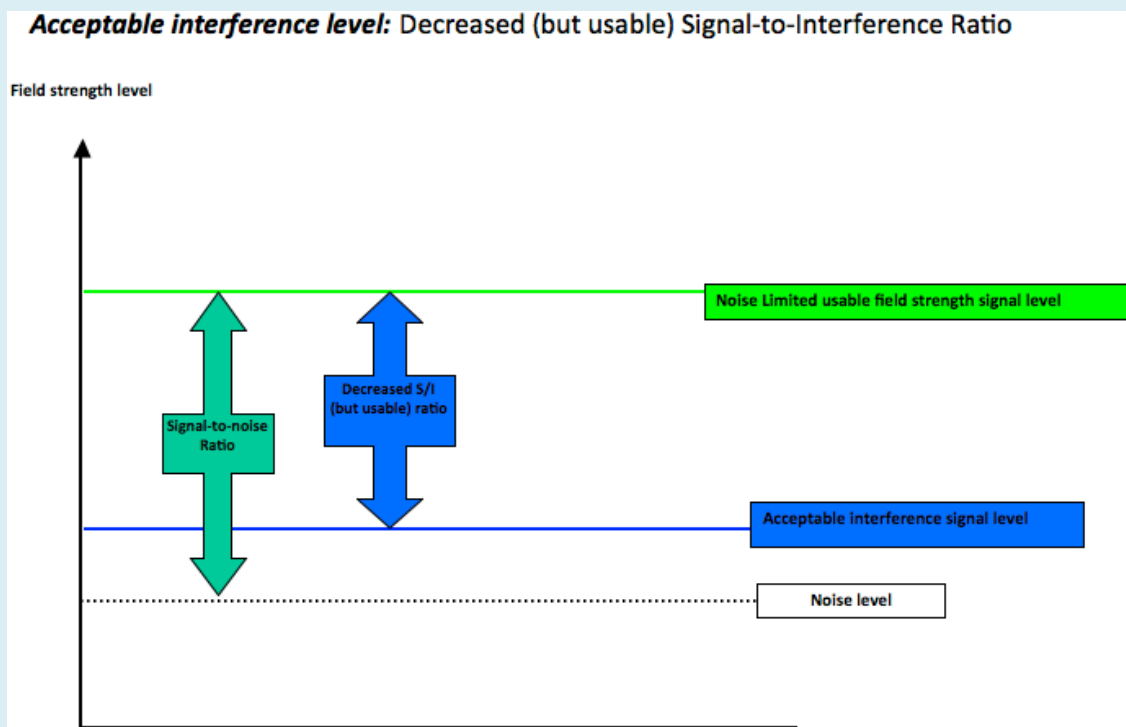
Figure H.1: Signal-to-noise ratio with no interference
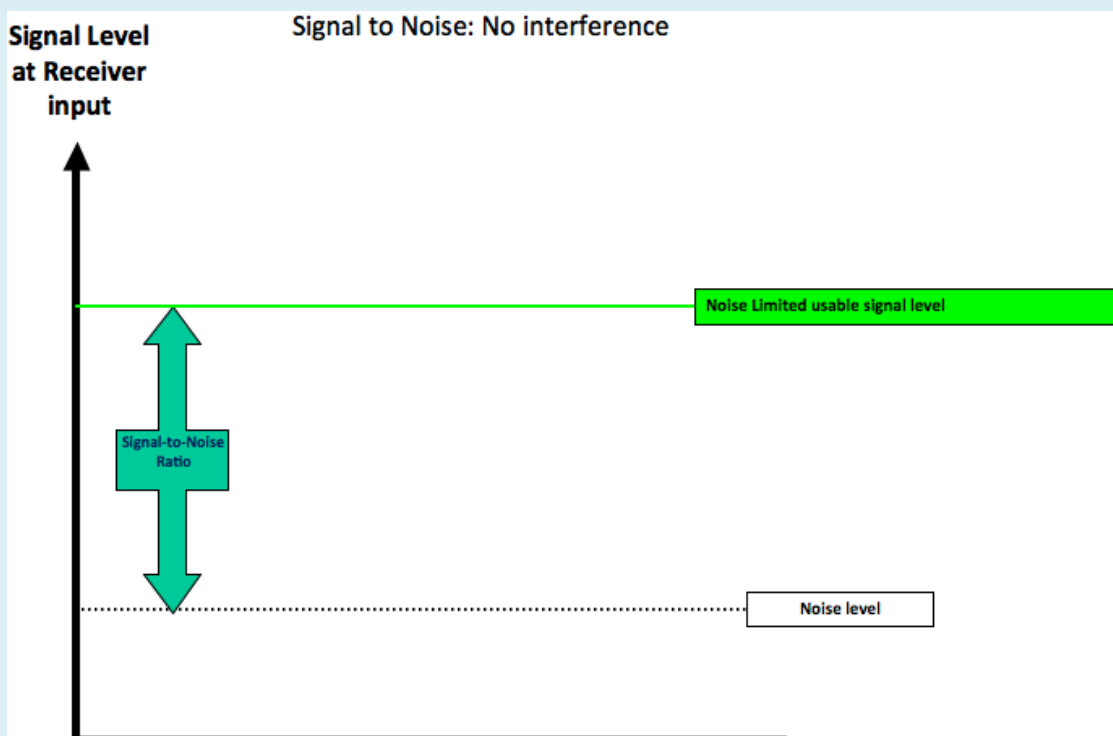
Source: ITU

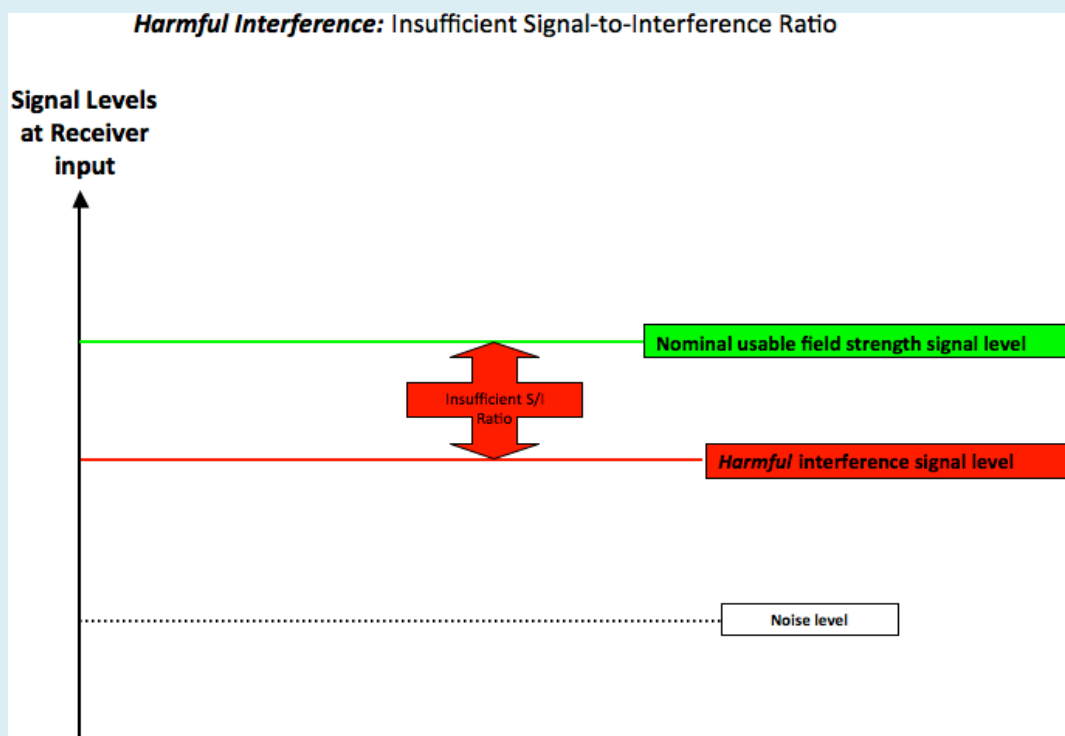**Figure H.2: Signal-to-noise ratio with permissible interference**

Source: ITU

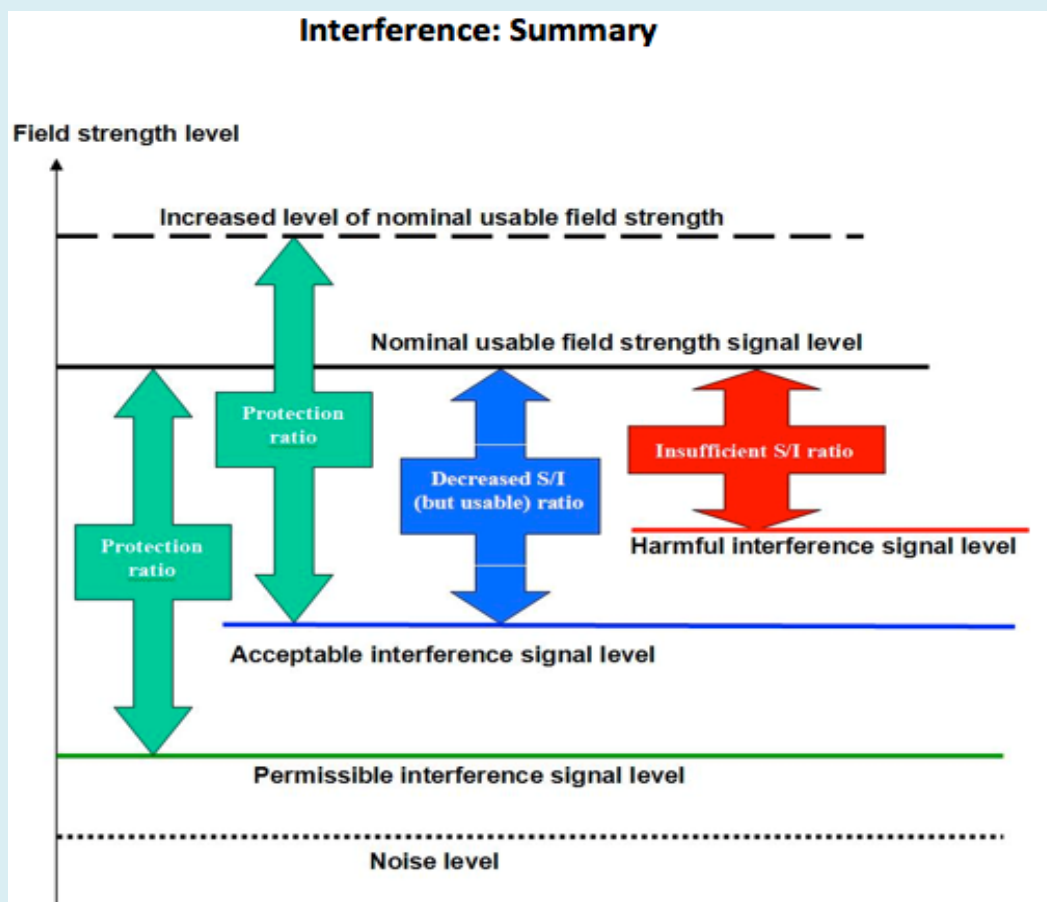**Figure H.3: Signal-to-noise ratio with acceptable interference**

Source: ITU

Figure H.4: Signal-to-noise ratio with harmful interference

Source: ITU

Figure H.5: Signal-to-noise ratio – summary

Source: ITU

H.3 Coordination between administrations

ITU has proposed modifications for the working document towards a preliminary draft of a new handbook ITU-R F.[Cross-border][90], which will deal with coordination. This will contain information for use by administrations in their bilateral and multilateral coordination dealing with sharing between stations of the land mobile service or between stations of the land mobile service and stations of other terrestrial services operating in neighbouring countries in the frequency bands above 29.7 MHz.

The Handbook will attempt to answer the following questions:

    i.   What methodologies guide administrations wishing to reach an agreement on compatibility?

    ii.   What technical and operational aspects need to be taken into account by administrations?

    iii.   Which methods can be used to determine criteria and corresponding triggers applicable to the methodology developed in accordance with (i)?

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[90]   Guidance for bilateral/multilateral discussions on use frequency range 29.7 MHz–[43.5 GHz] by fixed/land mobile systems (www.itu.int/md/R07-WP5A-C-0746/en)

ITU will work on establishing criteria for starting the process of coordination between administrations. These three key criteria relate to the distance between stations, the value of field strength of emissions and power flux-density. These are outlined below.

H.3.1 'A' Criterion – the distance between a concerned (transmitting or receiving) station in one country and reference point in the neighbouring administration.

This Criterion will be used for both fixed and land mobile services. The advantage of using this criterion is that it is relatively simple to apply and identify affected administrations. However, it suffers from the following disadvantages:

It could lead to a large number of frequency assignments that need to be agreed upon (when the criteria refers to hard specified limits) or to an insufficient number of such assignments (when the criteria refers to flexible/soft specified limits);

It could be specified accurately only when a comprehensive measurement radio wave propagation data base is available;

It is generally based on basic assumptions and therefore may not correspondence to real interference situation because specific station parameters and propagation conditions are not taken into account.

H.3.1.1 Interference scenarios

Under a given interference scenario, the coordination distance can be obtained by solving the relation between the power of the interfering signal received by the victim station and the distance from the interfering station using the following identity:

$$I = PT + [GR - DR(q)] - L(d) + [GT - DT (q')]$$

where:

I : Power at distance d originating from the interfering station (dBm);

PT : Maximum transmitting power level (dBm) in the reference bandwidth at the input to the antenna of the interfering station;

GT : Gain (dBi) of the transmitting antenna of the interfering station;

GR : Gain (dBi) of the receiving antenna of the interfered-with station;

DT : Antenna discrimination (dB) of the transmitting antenna (at different angles q');

DR : Antenna discrimination (dB) of the receiving antenna (at different angles q);

L(d): Total path loss (dB) for the Earth's curvature, with K = 1.33.

H.3.1.2 Intersystem radio-relay interference analysis

As an example for intersystem radio-relay interference analysis, a C/I ratio of greater than or equal to [65] dB can be assumed and expressed as follows:

$$C - I \geq [65] \text{ dB}$$

where:

C : Nominal received desired signal power (dBm);

I : Maximum tolerable interfering power (dBm).

$$C \geq PT + [GR - DR(q)] - L(d) + [GT - DT (q')] + [65]$$

There may be a reason to use the I/N ratio (- 6 dB) for determination of coordination distance.

H.3.2 'B' Criterion – the value of field strength created by emissions of station of one country at the reference point in the neighbouring administration.

Like 'A' above, this criterion has both advantages and disadvantages. It is more accurate that 'A' but contains additional complexity.

Advantages:

- Capability to take into account the relief and radio wave propagation details;
- Calculation accuracy rises when digital relief map is available.

Disadvantages:

- More complex to determine the affected administrations than "A" criteria;
- Digital relief map mutually agreed by administrations is expected to be available.

H.3.3 'C' Criterion – power flux-density

This criterion may be used for transmitting and receiving stations of both fixed and land mobile services. Like 'B' it allows for a more accurate calculation but is also more complex.

Advantages:

- May use power flux-density (pfd) values already specified by ITU in some frequency bands;
- Capability to take into account the relief and radio wave propagation features;
- Calculation accuracy rises when a digital relief map is available.

Disadvantages:

- More complex to determine the affected administrations than "A" criterion;
- Digital relief map concerted by administrations is expected to be available.

Table H.1 provides a summary of each of the key criteria and how they are measured. So far the frequency bands and the threshold values for each criteria are yet to be determined.

Table H.1: Measurement of key criteria

Criterion	Frequency Band	Measurement
'A' Criterion	TBD	Distance between concerned stations in neighbouring countries
'B' Criterion	TBD	Interference field strength at the reference point µV/m
'C' Criterion	TBD	Power flux-density, $dB(W/m^2 \cdot 4\ kHz)$

ITU is working on the establishment of the interference scenario and propagation conditions to be considered between administrations when the key criteria have been exceeded. This involves the identification of the minimum list of parameters for stations of fixed and land mobile services required for solving sharing/compatibility issues.

In order to address interference, there must be an agreement between administrations on a method to determine whether a certain criterion has been exceeded. To reach a successful agreement during cross-border negotiations, administrations should focus on:

- specific parameters according to frequency band;
- descriptions of technical requirements for each technology;
- relevant ITU-R Recommendations.

Likewise, the identification of affected stations of neighbouring administrations begins with:

- preliminary identification of the sites where the new systems will be deployed with geographical coordinates of each station;

- identification of the positions of the neighbours' systems operating close to the border and that use the same frequency band;
- preparation of a map of all stations affected;
- classification of stations according to their distance from the border.

For a stylised example of a station map with reference to national borders see Figure H.6.

Figure H.6: Stylised map of station positions
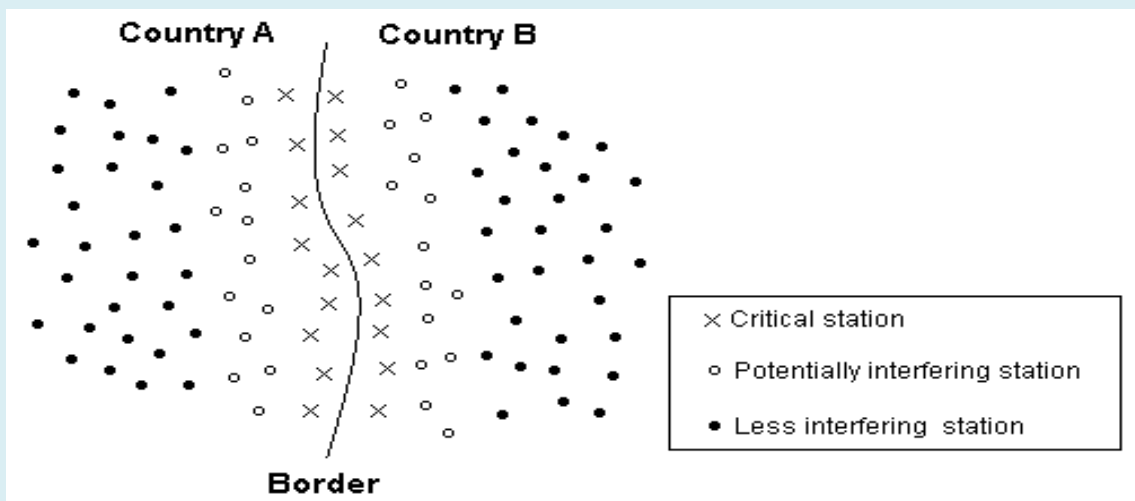
Source: ITU

Administrations should focus their consideration on those sites whose deployment can result effectively in harmful interference on the other side of the border. A maximum acceptable signal level at the border line for the frequency band under consideration must to be taken into account. This also requires the definition of possible technical and operational interference mitigation techniques for the stations of fixed and land mobile services.

H.4   Key European Communications Commission (ECC) documents

Table H.2 lists key European Communications Committee decisions, recommendations, planning criteria and reports relevant to this discussion.

Table H.2: List of key ECC documents

Document	Description
ECC/DEC/(05)05	Harmonised utilization of spectrum for IMT-2000/UMTS systems operating within band 2500-2690 MHz
ECC/DEC/(06)01	Harmonised utilization of spectrum for terrestrial IMT-2000/UMTS systems operating within the bands 1900-1980 MHz, 2010-2025 MHz and 2110-2170 MHz
ECC/DEC/(07)02	Availability of 3400-3800 MHz for the harmonized implementation of broadband wireless access
ECC/DEC/(09)03	Harmonised conditions for mobile/fixed communications networks (MFCN) operating in the band 790-862 MHz
ERC/REC/(01)01	Border coordination of UMTS
ECC/REC/(05)08	Frequency planning and coordination of GSM 900, GSM 1,800, E-GSM and GSM-R systems
ECC/REC/(08)02	GSM-900/UMTS-900, GSM-1800/UMTS-1800 frequency coordination
ECC/REC/(11)04	Frequency planning and frequency coordination for terrestrial systems for Mobile/Fixed Communication Networks (MFCN) capable of providing electronic communications services in the frequency band 790-862 MHz
ECC/REC/(11)05	Frequency planning and frequency coordination for terrestrial systems for Mobile/Fixed Communication Networks (MFCN) capable of providing electronic communications services in the frequency band 2500-2690 MHz
T/R 25-08	Planning criteria and coordination of frequencies in the Land Mobile Service in the range 29.7-921 MHz
ECC Report 097	Cross Border Interference for Land Mobile Technologies
ECC Report 108	Border Code Coordination between CDMA-PAMR Systems

Appendix I: List of references

The list of relevant ITU documents that have been referred for the preparation of national wireless broadband masterplans in the Asia Pacific region is given below:

1. Recommendation ITU-R M.1036-4 (03/2012) - Frequency arrangements for (IMT) in implementation of the terrestrial component of International Mobile Telecommunications the bands identified for IMT in the Radio Regulations (RR) www.itu.int/rec/R-REC-M.1036/en

2. Recommendation ITU-R M.1390 - Methodology for the calculation of IMT-2000 terrestrial spectrum requirements www.itu.int/rec/R-REC-M.1390/en

3. Recommendation ITU-R M.1457 - Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000) www.itu.int/rec/R-REC-M.1457/en

4. Recommendation ITU-R M.1579 - Global circulation of IMT-2000 terminals www.itu.int/rec/R-REC-M.1579/en

5. Recommendation ITU-R M.1768 - Methodology for calculation of spectrum requirements for the future development of the terrestrial component of IMT-2000 and systems beyond IMT-2000 www.itu.int/rec/R-REC-M.1768/en

6. Recommendation ITU-R M.687 - International Mobile Telecommunications-2000 (IMT-2000) www.itu.int/rec/R-REC-M.687/en

7. Recommendation ITU-R M.819 - International Mobile Telecommunications-2000 (IMT-2000) for developing countries www.itu.int/rec/R-REC-M.819/en

8. Recommendation ITU-R M.1182 - Integration of terrestrial and satellite mobile communication system www.itu.int/rec/R-REC-M.1182/en

9. Report M.2243 - Assessment of the global mobile broadband deployments and forecasts for International Mobile Telecommunications www.itu.int/pub/R-REP-M.2243

10. Report M.2023 - Spectrum requirements for International Mobile Telecommunications-2000 (IMT-2000) www.itu.int/pub/R-REP-M.2023

11. Report M.2024 - Summary of spectrum usage survey results www.itu.int/pub/R-REP-M.2024

12. Report M.2039 - Characteristics of terrestrial IMT-2000 systems for frequency sharing/interference analyses www.itu.int/pub/R-REP-M.2039

13. Report M.2078 - Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced www.itu.int/pub/R-REP-M.2078

14. Report M.2079 - Technical and operational information for identifying Spectrum for the terrestrial component of future development of IMT-2000 and IMT-Advanced www.itu.int/pub/R-REP-M.2079

15. ITU-D - REC-D.19 - Telecommunication for rural and remote areas www.itu.int/rec/D-REC-D.19/en

16. ITU-D – REC-D.18 - Potential benefits for rural telecommunications www.itu.int/rec/D-REC-D.18/en

17. ITU-D Rapporteur Group Meeting for Question 25/2: Access technology for broadband telecommunications including IMT, for developing countries www.itu.int/net3/ITU-D/stg/blkmeetings.aspx?blk=12755

Annex 1

List of acronyms and abbreviations

ACMA	Australia Communications and Media Authority
ASEAN	Association of South East Asian Nations
APT	Asia Pacific Telecommunity
ARPU	Average Revenue per User
AWS	Advanced Wireless Services
EGAN	3GPP Enhanced Generic Access Network
FCC	US Federal Communications Commission
FDD	Frequency Division Duplexing
GCF	Global Certification Forum
GPRS	General Packet Radio Service
GSM	Global System Mobile
LDCs	Least Developed Countries
LTE	Long Term Evolution
M2M	Machine to Machine
MP	Masterplan
MVNO	Mobile Virtual Network Operator
HetNets	Heterogeneous Networks
HSPA	High Speed Packet Access
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
IWLAN	Interworking Wireless LAN
MDGs	Millennium Development Goals
PPP	Public private partnership
PSTN	Public Switched Telephone Network
RAN	Radio Access Network
RLANS	Radio Local Area Networks
SON	Self Organising Network
TDD	Time Division Duplexing
UMA	Unlicensed Mobile Access
UMTS	Universal Mobile Telecommunications System
WBB	Wireless Broadband
W-CDMA	Wideband Code Division Multiple Access
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WRC-07	World Radiocommunications Conference 2007
WRC-12	World Radiocommunications Conference 2012
WRC-15	World Radiocommunications Conference 2015
3GPP	The 3rd Generation Partnership Project

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